WASTE MANAGEMENT IN MINING AND ALLIED INDUSTRIES

THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE

REQUIREMENTS FOR THE DEGREE OF

Bachelor of Technology

in

Mining Engineering

By

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Session: 2009-10

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CERTIFICATE

This is to certify that the thesis entitled **"WASTE MANAGEMENT IN MINING AND ALLIED INDUSTRIES"** submitted by Sri Sunil Kachhap, Roll No. 10605036 in partial fulfillment of the requirements for the award of Bachelor of Technology degree in Mining Engineering at the National Institute of Technology, Rourkela (Deemed University) is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University/Institute for the award of any Degree or Diploma.

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ACKNOWLEDGEMENT

I wish to express my deep sense of gratitude and indebtedness to **Dr. D.P.Tripathy**, Professor Department of Mining Engineering, N.I.T., Rourkela for introducing the present topic and for his inspiring guidance, constructive criticism and valuable suggestions throughout the project work.

I am thankful to all staff members of Department of Mining Engineering, NIT, Rourkela.

I am also thankful to **Sri A.M.Pujari,** DGM of EED Department Rourkela Steel Plant for giving me permission to carry out my project works in Rourkela Steel Plant. I am grateful to **Sri S.N.Xess,** AGM of EED Department for providing me all relevant information and have patiently extended all sorts of help for accomplishing my undertaking.

Thanks to **Sri D.Chattopadhyay,** General Manager (HRD) of Mahanadi Coalfields Limited for giving me permission to carry out my project work in two different mines of MCL.

Thanks to **Sri A.Barik,** Manager of BSL Mines for giving me permission and necessary support to carry out my project work in the mines.

Lastly, I would like to thank and express my gratitude towards my friends who at various stages had lent a helping hand.

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ABSTRACT

Waste management is the systematic assessment of potential hazards, disposal and proper utilization of waste in mining and allied industries. Due to waste there is a great environmental concern and resource constraint. These wastes can affect the environment through it intrinsic property. Proper planning is essential to manage the waste. Management indicates managing wastes in such a way that it would be beneficial in any way. In view of associated environmental hazards and their impacts on public health and safety, efforts must be made to minimize waste generation, systematic disposal practices must be followed and sound waste management methodologies need to be adopted.

In mining and steel industry, wastes are generated in every stage of the operations and are required to handle properly. The types of waste generated from both the industries are solid, liquid and gaseous wastes. So, waste management involves solid, liquid and gaseous waste management. Therefore the waste generated can be utilized or can be reused as raw material for other processes if not has to be disposed safely so that it will not affect the environment.

The objective of the waste management in mining and steel industry is to assess the waste disposal techniques used in both the industries as well as their waste management techniques. Field studies have been carried out on waste management in different industries, which include an open-cast limestone and dolomite quarry (BSL) mine, an opencast coal mine (Basundhara OCP) as well as an underground coal mine (Hirakhand Bundia) of Mahanadi Coalfields Limited (MCL) and Rourkela Steel Plant. In the BSL opencast mines that major waste problem is from the generation of the overburden and dust emission. In open cast coal mines due to high production and high mechanization the volumes of waste generated is more. The waste generated is managed by efficient methods. Solid wastes that are generated in the mines are being efficiently utilized for backfilling and the mine waste water generated is used for fighting fire and used for dust suppression measures. In underground coal mines waste type generated is different, so technique of waste management differs. Depending on the types of various processes to produce steel, diverse amount of wastes are generated in RSP as compared to waste generated from mining industry. In steel industry wastes contain some valuable resource in it, generally for solid waste. These solid wastes generated can be raw material for other process and in many cases can be reused. Water analysis for the R.S.P. and a mine was carried out to ascertain impact of waste generation by the two industries on the quality of the water that has been tested. Similarly soil samples from two different mines were analyzed and their characteristics have been reported.

Water samples of BSL mines and RSP were analyzed. For BSL mine water it was found from the result that concentration of magnesium and ammonia in the water was found to be excess. For RSP water magnesium, ammonia and total hardness of the water was found to be in excess.

It was observed from the field that the mines as well as RSP were lacking somewhere in the waste management practices. Mines pay less attention in waste management as they are much concern with their production of ore or coal. Due to use of outdated technology in the mines management of waste generated is a problem. In steel plant disposal of fly ash was a big problem. The reasons were that their generation was very high as compared to its disposal, as land is a constraint and in other case they were not efficiently utilized.

Waste management scenario in the above industries can be improved by following best practices. These practices are to improve production methods to mitigate all types of waste, exploit the value of waste. There should be implementation of strategies to reuse, recycle and to prevent waste from being harmful and manage waste properly. Regulations should be followed strictly for disposal and management of waste.

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INTRODUCTION

1.1 Overview

Waste generation is a major issue in every country, and waste quantities are generally growing. Total waste quantities continue to increase the problem in mining and allied industries. Unfortunately Waste is generated by activities in extraction of coal or ore from the mines and in steel industries by production of steel, which generates products which is generally regarded as an unavoidable by-product of economic activity waste generated from inefficient production processes, low durability of goods and unsustainable consumption patterns. The generation of waste reflects a loss of materials and energy and imposes economic and environmental costs on society for its collection, treatment and disposal. The impact of waste on the environment, resources and human health depends on its quantity and nature. The generation and of waste include emissions to air (including greenhouse gases), water and soil, all with potential impacts on human health and nature.

Waste management has assumed importance due to environmental hazard and depletion of the resource of all most all the minerals. Considering the bulk quantity which forms the wastes in the mining industries, its utilization is posing a challenge to the environment and our natural resources. So, there is an accompanying need of recovering and utilization resource from waste material and to minimize the impact of waste on the environment.

Waste from the mining or extractive operations (i.e. waste from extraction and processing of mineral resources) is one of the largest waste streams in the world. It involves materials that must be removed to gain access to the mineral resource, such as topsoil, overburden and waste rock, as well as tailings remaining after minerals have been largely extracted from the.

Mining waste from the exploration and removal of the minerals cast challenges for many local inhabitants. Mining extraction and beneficiation can create environment problems including acid mine drainage, erosion and sedimentation, chemical release, fugitive dust emission, habitat destruction, surface- and ground water contamination, and subsidence.

Steel making from steel industry gives rise to toxic gases, liquids and solid wastes from various operations. These operations include the subcategories: coke-making, iron-making (blast furnace, sintering, etc.), steel-making, casting, hot-forming and finishing. In steel industries the waste generated is during the extraction process of the metals in each process described above. Air emissions are generated as both particulate and gaseous emissions in the transportation of raw materials and in processing operation, liquid waste is generated during quenching process and solid waste is the by-product that are generated during steel making.

Effective waste management can help us to meet regulatory requirements, recycling targets and reduce disposal costs. We also work to eliminate or reduce waste at source, to increase the ability to recover, reuse and recycle as well as reduce hazardous content.

Advantages of waste utilization:

1. The recovery of addition raw material through the resources recovery.
2. Extending the mineral resources.
3. Development of useful product from recounted material.
4. Reduce pollution and balance ecology.
5. Source of addition income.
6. Employment of persons in small scale industries using wastes.

1.2 Objectives of the Project:

- To study the waste disposal and management practices in coal and non-coal mines.
- To study the waste disposal and management practices in Rourkela steel plant.
- To analyse water quality of BSL mine and Rourkela steel plant.
- To analyse soil quality of the BSL mine and Basundhara mine.
- To suggest best practices in waste management in mines and steel plant under study.

CHAPTER 2

LITERATURE REVIEW

CHAPTER 2

LITERATURE REVIEW

2.1 WASTE MANAGEMENT IN MINING INDUSTRY

Operation of the mining industry includes mining, mineral processing and metallurgical extraction produce solid, liquid and gaseous wastes. Mines waste can be further classified as solid mining, processing and metallurgical wastes and mine waste water.

- ***Mining waste*:** Mining wastes either do or do not contain ore mineral, industrial minerals, metals, coal or mineral fuels, or the concentration of the mineral, metals, coal or mineral fuels is sub economic. For example, the criterion for the separation of waste rock from the metalliferrous ore and for the classification of material as economic or sub economic is the so-called “cut-off grade”. It is based on the concentration of the ore element in each unit of the mined rock and on the cost of the mining that unit. As a result, every mine has different criterion for separating mine waste from ore. Mining waste includes overburden and waste rock excavated and mined form surface and underground operation. Waste rock is essentially wall rock material removed to access and mine ore. In coal mining, waste rocks are referred to as “spoils”.

  Mining waste is heterogeneous geological material and may consist of sedimentary, metamorphic or igneous rock, soil and loose sediments. As a consequence, the particle sizes ranges from the clay size particles to boulder size fragments. The physical and chemical characteristic of mining waste vary according to their mineralogy and geochemistry, type of mining equipment, particle size of the mined material, and moisture content. The primary sources for these materials are rock, soil, sediments from the surface mining operation, especially open pits and to a lesser degree rock removed from the shaft, haulage ways and underground workings. Once the metalliferous ore, coal, industrial minerals or mineral fuels are mined, they are processed to extract the valuable commodity. In the contrast, mining wastes are placed in the large heaps on the mining lease. Nearly all mining operations generate mining waste, often in very large amounts.

- ***Processing wastes*:** Ore are usually treated in physical process called beneficiation or mineral processing prior to any metallurgical extraction. Mineral processing techniques may include: simple washing of the gravity, magnetic, electrical or optical sorting; and the addition of process chemicals to crushed and sized ore in order to aid the separation of the sought after mineral from gangue during flotation. These treatment method results in production of “processing wastes”. Processing wastes are defined herein as the portion of the crushed, milled, ground washed or treated resource deemed too poor to be treated further. The definition thereby includes tailings, sludges and waste water from the mineral processing, coal washing and mineral fuel processing. “Tailings” are defined as the processing wastes from a mill, washery or concentrate that removed the economic metals, minerals, mineral fuels or coal from the mined resource.

The physical and the chemical characteristic of the processing waste varies accordingly to the mineralogy and the geochemistry of the treated resource, type of processing technology, particle size of the crushed material and the type of process chemicals. The particle of the processing waste can range in size from colloidal size to fairly coarse, gravel size particles. Processing waste can be used.

For back filling mine workings or reclamation of mined areas, but alternatively method of disposal must be found for most of them. Usually this disposal simply involves dumping the waste at the surface next to the mine workings. Most processing waste accumulates in the solution or as sediment slurry. These tailings are generally deposited in the tailing dam or pond which has been constructed using mining waste or other earth material available on or near the mine site.

❖ ***Metallurgical wastes***: Processing of metal and industrial ores produces an intermediate product, a mineral concentrate, which is the input to the extractive metallurgy. Extractive metallurgy is based on hydrometallurgy (e.g. Au, U, Al, Cu, Zn, Ni, P) and pyrometallurgy (e.g. Cu, Zn, Ni, Pb, Sn, Fe), and to the lesser degree on electrometallurgy (e.g. Al, Zn). Hydrometallurgy leaching of the ore with cyanide solution is a common hydrometallurgical process to extract the gold. The process chemical dissolves the gold particle and a dilute, gold-laden solution is produce which is then processed further to recover the metal. In contrast, pyrometallurgy is based on the breakdown of the crystalline structure of the ore mineral by heat whereas electrometallurgy uses electricity. These metallurgy processes destroy the chemical combination of the element and result in production of the various waste products including atmospheric emission, flue dust, slag, roasting products, waste water and leached ore.

❖ ***Mine waste water:*** It includes mine and mill water. Mining, mineral processing and metallurgical extraction not only involves the removal and processing of rock and the production and the disposal of solid waste, but also the production, use and disposal of mine water. “Mine water” originates as a ground or meteoric water which undergoes compositional modifications due to the mineral water reaction at the mine site including surface water and the subsurface ground water.

Water is needed at the mine site for dust suppression, mineral processing, coal, washing and hydrometallurgical extraction. The term “mining water” is used here in a general sense to refer to water which run off or flow though a portion of a mine site and had contact with any of the mine workings. “Mill water” is that water that is used to crush and size the ore. “Processing water” is water that is used to process the ore using hydrometallurgical extraction techniques. The water commonly contains process chemical. At some stage of mining operation, water is unwanted and has no value to the operation. Such mine water is generated and disposed of at various stages during mining, mineral processing and metallurgical extraction. Water of poor quality requires remediation as it is uncontrollable discharge, heat, suspended solid, bases, acids and dissolves solids including process chemical, metals, metalloids, radioactive substances or salts. Such a release count results in a pronounced negative impact on the environment surrounding the mine site.

“Acid mine drainage” (AMD) refers to the particular process whereby low pH mine water is formed from the oxidation of sulfide minerals. In fact, the acid stream draining such ores and rock can contain high levels of metals and metalloids that exceed water quality standards and result in toxic effect to the aquatic life.

2.1.1 ENVIRONMENTAL IMPACTS OF MINING WASTES

Mining operations, both open-pit and underground, typically produce large volumes of tailings deposits and waste rock piles. They may cause air pollution, water pollution and land degradation problems. These wastes can affect the environment through the following intrinsic criteria:

- its chemical and mineralogical composition,
- its physical properties,
- its volume and the surface occupied,
- The waste disposal method.
- climatic conditions liable to modify the disposal conditions,
- geographic and geological location,
- Existing targets liable to be affected (man and his environment).

Thus, identification of the environmental risks associated with the exploitation of mines and quarries and with ore processing not only requires the characterization and quantification of the different types of waste, as well as a knowledge of the processes used, but also an assessment of the vulnerability of the specific environments contingent upon the geological and hydro-geological conditions and peripheral targets. Since this is a generic description, it is important to keep in mind that not all plants or deposits will release pollutants. Meteoric precipitation can transfer pollutant from a tailings dam or a processing plant to the river if the waste management is not efficient. If there is no impermeable layer, below the deposit, the infiltration of meteoric precipitation through deposit can transfer the pollutants to the river *via* groundwater flow.

2.1.2 MINING WASTE DISPOSAL TECHNIQUES

Disposal of coarse mining waste consists in conversing large areas with dumps or in filling abandoned open-pits. There are two major problems encountered during waste dump construction. First is the availability of suitable land (which is technically, environmentally and economically viable) then the control over its construction. Technically suitability means the land have the capacity to accommodate the quantity of waste and can withstand the ground bearing pressure. Environmentally suitability means allowable contamination to ground/surface water; restoration of top soil both area of disposal and area of mining etc. Tailing and other finer waste can be disposed in various ways. By order of importance, the disposal of tailings is generally by:

- Terrestrial impoundment (tailings ponds),
- Underground backfilling,
- Deep water disposal (lakes and sea), and
- Recycling.

Figure 2.1. Tailing Pond [22]

2.1.3 MANAGEMENT OF MINING WASTES

Waste management is the collection, transport, processing, recycling or disposal of waste materials, usually ones produced by human activity, in an effort to reduce their effect on human health or local aesthetics or amenity. A sub focus in recent decades has been to reduce waste materials' effect on the natural world and the environment and to recover resources from them. Waste management can involve solid, liquid or gaseous substances with different methods and fields of expertise for each.

Proper planning is essential to manage the mining wastes. Mining wastes generated in every stage of the operations are required to handle immediately. The objectives should be aimed towards – minimization of waste generation, prevention of wastes to become hazardous, alternative use of the generated wastes and systematic waste disposal.

2.2 WASTE MANAGEMENT IN STEEL INDUSTRY

Introduction

Iron and steel industry characteristically is a heavy industry. All its raw materials are heavy and colossal. They encompass iron-ore, coking coal and limestone. Location of this industry is thus governed by its proximity to raw materials, predominantly coking coal.

Crude steel production in the 66 countries reporting to the World Steel Association totaled 1326.5 (mmt) in 2008. In 2007, total world crude steel production was 1,351.3 million metric tonnes (mmt). The biggest steel producing country is currently China, which accounted for 36.6% of world steel production in 2007. India stands fifth position in the list of the steel production accounting 55.2 million tons of steel production in 2008.

This is a list of countries by steel production in 2007 and 2008, based on data provided by the World Steel Association, accessed in May 2009.

Table 2.1 Crude Steel Production (million tonnes)

(http://en.wikipedia.org/wiki/Steel_production_by_country)

Rank	Country/Region	2007	2008
—	World	1,351.3	1326.5
1	People's Republic of China	494.9	500.5
—	European Union	209.7	198.0
2	Japan	120.2	118.7
3	United States	98.1	91.4
4	Russia	72.4	68.5
5	India	53.1	55.2
6	South Korea	51.5	53.6
7	Germany	48.6	45.8
8	Ukraine	42.8	37.1
9	Brazil	33.8	33.7
10	Italy	31.6	30.6

With the increase in steel production, solid waste i.e. its slag production also increased in the world and in 2008 it was 400 million tones. Actual production data in India are unavailable but may be estimated as being in the range of 17 to 23 million tons in 2008.

2.2.1 MAJOR STEEL PLAYERS IN INDIA

Steel Authority of India Limited (SAIL) is the leading steel-making company in India. It is groups of fully integrated steel plants producing both basic and special steel for domestic construction, engineering, power, railway, automotive and defense industries and for sale in export markets. The Government of India owns about 86% of SAIL's equity and retains volting control of the company. Major units of SAIL are as under.

- Integrated steel plant
- Bhilai Steel Plant (BSP) in Chhattisgarh
- Durgapur Steel Plant (DSP) in West Bengal
- Rourkela Steel Plant (RSP) in Orissa
- Bokaro Steel Plant (BSL) in Jharkhand

SAIL Special Steel Plant

- Alloy Steel Plant (ASP) in West Bengal
- Salem Steel Plant (SSP) in Tamil Nadu
- Visvesvaraya Iron and Steel plant (VISL) in Karnataka

Subsidiaries

- Indian Iron and Steel Company (IISCO) in West Bengal
- Maharashtra Electro smelt Limited (MEL) in Maharashtra
- Bhilai Oxygen Limited (BOL) in New Delhi

Others major steel producers are

- Tata Steel
- Essar Steel
- Jindal Vijaynagar Steels Ltd
- Jindal Strips Ltd
- JISCO
- Saw Pipes
- Uttam Steels Ltd
- Ispat Industries Ltd
- Mukand Ltd
- Mahindra Ugine Steel Company Ltd
- Tata SSL Ltd
- Usha Ispat Ltd
- Kalyani Steel Ltd
- Electro Steel Castings Ltd
- Sesa Goa Ltd
- NMDC
- Lloyds SteeI Industries Ltd

STEEL AUTHORITY OF INDIA LIMITED (SAIL)

Steel Authority of India Limited (SAIL) is a company registered under the Indian Companies Act, 1956 and is an enterprise of the Government of India. It has five integrated steel plants at

- ❖ Bhilai (Chhattisgarh),
- ❖ Rourkela (Orissa),
- ❖ Durgapur (West Bengal),
- ❖ Bokaro (Jharkhand) and
- ❖ Burnpur (West Bengal).

Table 2.2 Indian Iron & Steel Production of SAIL (in Million Tonnes)
(http://steel.nic.in/development.htm#LINKD1)

Item	**2006-07**	**2007-08**	**2008-09**	**2009-10 (Apr-Dec)**
Pig Iron	4.99	5.314	5.28	4.30
Carbon Steel	55.146	58.233	59.02	48.11

2.2.2 STEEL PRODUCTION FROM IRON ORE

Steel is an alloy of iron usually containing less than 1% carbon. It is used most frequently in the automotive and construction industries. Steel can be cast into bars, strips, sheets, nails, spikes, wire, rods or pipes as needed by the intended user.

Steel production at an integrated steel plant involves three basic steps.

1. The heat source used to melt iron ore is produced i.e. coke making.
2. Next the iron ore is melted in a furnace.
3. Finally, the molten iron is processed to produce steel.

These three steps can be done at one facility; however, the fuel source is often purchased from off-site producers.

Coke making

Coke is a solid carbon fuel and carbon source used to melt and reduce iron ore. Coke production begins with pulverized, bituminous coal. The coal is fed into a coke oven which is sealed and heated to very high temperatures for 14 to 36 hours. Coke is produced in batch processes, with multiple coke ovens operating simultaneously.

Heat is frequently transferred from one oven to another to reduce energy requirements. After the coke is finished, it is moved to a quenching tower where it is cooled with water spray. Once cooled, the coke is moved directly to an iron melting furnace or into storage for future use.

Iron making

During iron making, iron ore, coke, heated air and limestone or other fluxes are fed into a blast furnace. The heated air causes the coke combustion, which provides the heat and carbon sources for iron production. Limestone or other fluxes may be added to react with and remove the acidic impurities, called slag, from the molten iron. The limestone-impurities mixtures float to the top of the molten iron and are skimmed off, after melting is complete.

Sintering products may also be added to the furnace. Sintering is a process in which solid wastes are combined into a porous mass that can then be added to the blast furnace. These wastes include iron ore fines, pollution control dust, coke breeze, water treatment plant sludge, and flux. Sintering plants help reduce solid waste by combusting waste products and capturing trace iron present in the mixture. Sintering plants are not used at all steel production facilities.

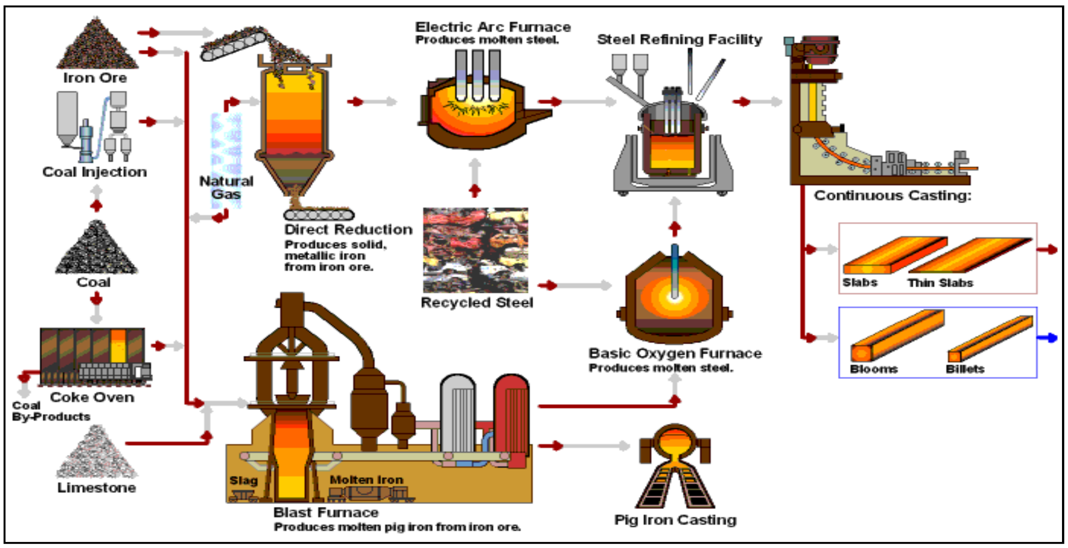

Figure 2.2. Steel Making Flowchart [25]

Basic oxygen steelmaking (BOS, BOF, Linz-Donawitz-Verfahren, LD-converter) is a method of primary steel making in which carbon-rich molten pig iron is made into steel. The LD-converter is named after the Austrian place names Linz and Donawitz (a district of Leoben). The vast majority of steel manufactured in the world is produced using the basic oxygen furnace. Modern furnaces will take a charge of iron of up to 350 tons and convert it into steel in less than 40 minutes. The LD converter is a refined version of the Bessemer converter where blowing of air is replaced with blowing oxygen.

Blowing oxygen through molten pig iron lowers the carbon content of the alloy and changes it into low-carbon steel.

The process is known as basic due to the pH of the refractories - calcium oxide and magnesium oxide - that line the vessel to withstand the high temperature of molten metal.

2.2.3 SOLID WASTE GENERATION IN STEEL PLANTS AND ITS REUTILIZATION

The operations in an integrated steel plant are very complex. Several other activities such as power generation and production of refractories are also performed in varying degree inside the steel works. A vast quantity of raw material are handled and processed and solid wastes are generated at every stage of operation. These wastes have wide ranging impact on the environment. These solid wastes contain valuable material which can be recovered and recycled in the process.

Various steel industries in the country in the area of waste utilization which includes production of cement from BF slag, use of LD slag as a soil conditioner, LD slag recycling through sinter routes, manufacture of fly ash bricks and light weight aggregates, agglomeration and recycle of lime fines, reuse of refractory wastes products and use of coke breeze in sinter making.

Production of steel involves several operations. It starts from the naturally occurring raw material like iron ore, coal and flux stones to produce hot metal in blast furnace, conversion of hot metal into steel and the subsequent rolling of steel in finished product in the rolling mills. Several other activities such as power generation and production of refractories are also performed in varying degree inside the steel works. Large quantities of wastes are generated in view of the above activities. These wastes have wide ranging impacts on the environment. These solid wastes are classified into three basic categories:

1) Wastes which are hazardous and must be treated suitably before throwing them as waste.
2) Wastes which are not hazardous and recovery recycle and reuse of valuable in it could be done economically.
3) Wastes which are not hazardous but recovery recycle and reuse may not be economical.

In many cases, these solid wastes contain valuable material which can be recovered and recycled in the process. Recycling and utilization of these solid wastes through an integrated waste management has gained special significance due to several factors such as economic advantage of the primary resources, better and cleaner environment, conservation of energy and water and compliance with the law.

To make one tone of crude of steel even with the good raw materials and efficient operation, 5 tonnes of air, 2.8 tonnes of raw material and 2.25 tonnes of water are required. These will produce in addition to one tonnes of crude steel, 8 tonnes of moist dust laden gases and 0.5 tonnes of solid wastes. However, in SAIL plants, this figure varies from 820 kg/tcs to 1045kg/tcs which are still very high. Solid wastes generated at various stages of operation in steel industries of other countries as well as in India in table 1. The schematic presentation of steel making is shown in Fig 1. From the above it is clear that the main solid waste comprises:

a) Blast furnace slag.
b) Steel making slag.
c) Sludge from sinter plant and blast furnace gas cleaning systems.
d) Dust recovered from dedusting system.
e) Mill scale.
f) Fly ash
g) Waste refractories.
h) Raw material spilled out of the carrying system.
i) Waste consumables

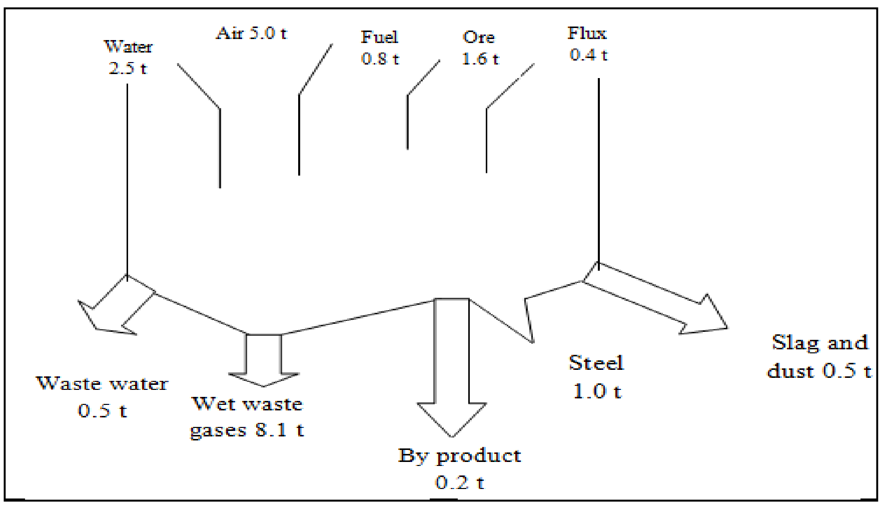

Figure 2.3 Schematic Diagram of Steel Making (Agarwal, 1999)

2.2.4 MAJOR SOLID WASTES GENERATED IN STEEL PLANT

- **Iron making**

  The major solid wastes generated from iron making process are as follows:

  i. Air cooled BF slag.

ii. Granulated BF slag.
iii. Desulphurization slag.
iv. Flue dust.
v. GCP sludge.
vi. Pig iron.

- **Steel making**
  i. BOF slag.
  ii. BOF sludge.
  iii. Lime dust.
  iv. Steel scrap.

- **Rolling mills:**
  i. Mill scale.
  ii. Silicon steel mill sludge.

- **Coke Oven**
  Coke breeze

- **Coal Chemical department**
  i. Sulphur sludge.
  ii. Tar sludge.

- **Power generation**
  i. Fly ash.
  ii. Bottom ash/clinker.

- **Others**
  i. Used refractory.
  ii. Oil refining sludge.
  iii. Machine shop turning.

Category of Solid Waste

There are basically three categories of solid wastes. They are as follows:

1. Ferruginous solid wastes.
2. Non-ferruginous solid wastes.
3. Fly ash.

Ferruginous Solid Wastes

Solid waste which contain more amount of iron particles are considered as ferruginous solid wastes. These solid wastes are of more demand. They can be recycled and reused in various ways. These wastes contain more percentage of iron particles.

Example: Blast furnace flue dust, gas cleaning plant (GCP) sludge, LD sludge, sinter plant sludge, mill scale are some of the major ferruginous solid wastes.

Non-Ferruginous Solid Wastes

Solid wastes which do not contain iron particles are considered as non-ferruginous solid waste.

Example: acetylene sludge, refractory brick, limes fines etc.

Acetylene Sludge

- Acetylene sludge is composed of SiO_2 = 4 to 6, CaO = 60 to 70, Al_2O_3 = 1 to 3.
- There are two acetylene plants for production of acetylene gas from calcium carbide.
- Entire quantity of acetylene sludge which is generated from these plants is being sold to private parties.
- Acetylene sludge can be utilized gainfully for the neutralization of acidic effluent and white washing of buildings.

Refractory Bricks

- Refractory bricks have a major role in processes which take place in the steel plant.
- They are of a great use as a container for hot metal whose temperature is approximately 950-1300 degrees.
- They have a high melting point.
- Refractory bricks are highly heat resistant.
- They are mostly generated from furnace, coke oven, LD converters, kilns etc.
- These refractory bricks (used and broken both) are further recycled and sold for further use.

Lime Fines

- Lime fines are mostly generated from lime, dolomite and brick plant, calcining plant etc.
- They are used as a neutralizing agent in coal rolling mills (CRM).
- They are also used in trimming addition in sinter making process.

Fly Ash

- Major source of fly ash generation are the coal based thermal power plants.
- It is the byproduct of the combustion of pulverized coal in thermal power plants.
- It is used in manufacturing cement.
- Used in making fly ash based bricks.
- Helps in raising ash pond dyke height.
- Used in plastering process.
- It plays a major role in conditioning of soil.
- Helps in filling land or mines.
- Helps in making roads and tiles.
- Helps in making cellular concrete.
- Helps in making fly ash lime gypsum products.

2.2.5 SOLID WASTE MANAGEMENT

With the production of 15.58 MT of crude steel during 2007-08, the steel plants have generated 5.8 MT of BF slag, 1.4 MT of SMS slag and 0.8 MT of other process wastes. SAIL has effectively adopted waste minimization strategies including conservation at source, recovery and recycling. The solid waste generation over the years has been reducing and that of utilization has been increasing, as is evident from the following table:

Table 2.3 Solid Waste Generation in SAIL (http://www.sail.co.in/), [28]

Year	**Solid Waste**	
	Generation (in million tonnes)	Utilization (%)
2005-06	7.841	70
2006-07	7.816	75
2007-08	8.029	79
2008-09	8.028	78.6

2.2.6 ENVIRONMENTAL IMPACTS OF STEEL PLANT WASTE

Iron making in the BF produces a slag that amounts to 20 to 40 percent of hot metal production. BF slag is considered environmentally unfriendly when fresh because it gives off sulfur dioxide and, in the presence of water, hydrogen sulfide and sulphuric acid are generated. These are at least a nuisance and at worst, are potentially dangerous. Fortunately, the material stabilizes rapidly when cooled and the potential for obnoxious leachate diminishes rapidly. However, the generation of sulphuric acid causes considerably corrosion damage in the vicinity of blast furnace. In Western Europe and Japan, Virtually all slag produced is utilized either in cement production or as a road filling. In Egypt, almost two-thirds of the BF slag generated is utilized in cement production. Some 50 to 200 kg of BOF slag is produced for every metric ton of steel made in the basic oxygen furnace, with an average value of 120kg/metric ton. At present about 50 percent of BOF slag is being utilized worldwide, particularly for road construction and as addition to cement kiln.

Recycling of slag has become common only since the early 1900s. The first documented use of BF slag was in England in 1903, slag aggregates were used in making asphalt concrete. Today, almost all BF slag is used either as aggregate or in cement production. Steel for making slag is generally considered unstable for use in concrete but has been commercially used as road aggregates for over 90 years and as asphalt aggregates since 1937, steel-making slag can contain valuable metal and typical processing plant are designed to recover this metal electromagnetically. These plants often include crushing units that can increase the metal recovery yield and also produce material suitable as construction aggregates. Although BF slag is known to be widely used in different civil engineering purposes, the use of steel slag has been given much less encouragement.

BF dust and sludge are generated from the processing and cleaning, either by wet or dry means, the dust and sludge typically are 1 to 4 percent of hot metal production, these material are less effective utilized than BF slag. In some cases, they are recycled through the sinter plant, but, in most cases, they are dumped and land filled. Finding better solution for the effective utilization of BF slag and sludge is an important problem. BOF dust and sludge are generated during the cleaning of gases emitted from the basic oxygen furnace. The actual production rate depends on the operation circumstances. It may range from about 4 to 31 kg/metric ton of steel produced, and has a mean value of about 18 kg/metric ton. The disposal or utilization of BOF dust and sludge is one of the critical environmental problems in some countries.

Electrical arc furnace produces about 116 kg of slag for every metric ton of molten steel. Worldwide, about 77 percentage of the slag produced in EAFs is reused or recycled. The remainder is land filled or dumped. Due to the relatively high iron content in EAF slag, screens and electromagnetic conveyors are used to separate the iron to be reused as raw material. The EAF slag remaining is normally aged for at least six months before being reused or recycled in different application such as road building. All efforts in Egypt have focused on separating the iron from EAF slag without paying enough attention to the slag itself. However, pilot research work conducted at Alexandria University in Egypt has investigated the possibility of utilizing such slag. The test result proved that slag asphalt concrete could, in general fulfill the requirements of the road-paving design criteria.

2.2.7 WASTE MANAGEMENT IN STEEL PLANT

From the name itself, it indicates managing wastes in such a way that it would be beneficial in any way. Waste management is the collection, transport, processing, recycling or disposal of waste material, usually one produced by human activities with an effort to reduce their effect on human health or local aesthetics or amenity. Waste management involves solid, liquid and gaseous waste management.

Solid Waste Management

- Solid waste generation is controlled by efficient and optimum use of raw material.
- Solid wastes should be disposed properly through a proper disposal system.
- New technologies should be adopted for eco-friendly solid waste disposal.
- Transportation of solid waste from generation point to disposal point should be in a controlled and proper way.
- Displaying the area as solid waste disposal area.
- If possible, selling some of the solid wastes to be further used in some other ways converting waste into wealth.

Liquid Waste Management

- All major and maximum liquid wastes should be recycled.
- Monitoring of the reclaimed water drawn from the respective plants.
- Liquid wastes should be disposed properly through the proper and efficient disposal system.
- Transportation of liquid wastes from the generation point to disposal point should be in a controlled and proper way.
- Displaying the area as liquid waste disposal area.
- Selling some of the liquid waste to be used in beneficial ways.

Gaseous Waste Management

- Recycling of dust product to the respective process.
- Online monitoring of combustion products such as SO_x, CO, NO_x analyzer at stack dust emission level.
- Monitoring ESP efficiency & stack volume.
- Measuring and monitoring of ambient air quality.

CHAPTER 3

WASTE MANAGEMENT IN MINING AND ALLIED INDUSTRIES: CASE STUDIES

CHAPTER 3

3.1 WASTE MANAGEMENT IN THE BISRA STONE LIME COMPANY LIMITED

3.1.1 Introduction

Bisra Stone Lime Company Limited Mines is an opencast mine located at Birmitrapur District-Sundargarh Orissa on NH-23 and towards North of Rourkela at a distance of 30 KM and it is well connected by rail also. The lease hold area of mines is 1961.93 Acres or 793.966 Hectares

Location:-The geographical location of the mines falls between

- Latitude: $22^{o}24'19.7$ to $22^{o}25'00$
- Longitude: $84^{o}40'56.6$ to $84^{o}45'24$

Figure 3.1.1 Location of BSL Mines

Geology of the mines

The rocks of this area belong to the Birmitrapur stage of the Gangpur series of middle Dharwarian age. All the rocks of this series are meta-sedimentary in nature. In the lease hold proper Limestone overlies Dolomite i.e. the limestone is younger than dolomite. The general strike of the mineral body is nearly east-west and average dip is 60^o towards North. Limestone is crystalline and gray in colour but dolomite is fine grain shows gray to white varieties. Both are suitable for steel making.

Reserve and grade: -

Limestone**:** The total reserve of Limestone to be around 400 Million Tonnes. During mining it has been found 60% is good stone (BF Grade) so total BF grade is about 240 Million Tonnes.

Table 3.1.1 Composition of Limestone (in %) [14]

Ins	8.00 – 12.00
SiO_2	5.00 – 9.00
Al_2O_3:	1.50 – 2.50
Fe_2O_3:	0.60 – 1.50
CaO	43.50 – 46.50
MgO	3.50 – 5.50

Dolomite: The Dolomite reserve will be approx. 240 million tonnes. From the quality control in the mines it has been noticed that 70% is good stone (BF Grade). So based on the calculation total B.F.Grade Dolomite will be around 170 million tones.

Table 3.1.2 Composition of Dolomite (in %) [14]

Ins	5.00 – 7.50
SiO_2	3.00 – 5.50
Al_2O_3:	0.80 – 1.20
Fe_2O_3:	0.50 – 0.80
CaO	28.00 – 29.50
MgO	19.50 – 21.00

Mining Plan

For convenience of mining, the deposit has been divided into four mines, viz. Kaplas East, Kaplas West, Gurpahar and Patpahar. There are very low grade stones in between the limestone and dolomite bands which mean mining has to be carried out in a selective manner. The estimated reserves of limestone and dolomites are 375 MT and 265 MT respectively.

Mining technology

Jack-hammer drill system is being used for overburden removal. Limestone extraction is done by conventional drilling & blasting manual sizing of the limestone at the mine site.

Limestone wining and transportation

Total limestone production is done by drilling & blasting with dumper loading and transportation system. Blasted coal is loaded by loaders on to dumpers and transported to the apron feeder of feeder breaker. Part of sizing in done on the mine site manually so as to obtain the apron feeder feed size. Further crushing is done in the crusher from which various product of different sizes are obtained and are then directly transported to the railway sidings and from there to the customers.

Table 3.1.3 Specification of Machineries [14]

Dumpers: Tata Movers	
Capacity	25 tons
Power	395 hp
Total number	5 Nos.
Loader: JCB 3d	
Bucket capacity	0.8 m^3
Power	50 hp
Total number	3 Nos.
Loader: HM 2021	
Bucket capacity	1.7 m^3
Power	124
Total number	2 Nos.

3.1.2 PATPAHAR QUARRY OF BSL MINES

The waste management practices in Patpahar quarry, one of the quarries of the BSL mines. Mineral deposit found: - Dolomite

Table 3.1.4 Details of Patpahar quarry [14]

Length of Patpahar Quarry	712.5 m
Breadth of Patpahar Quarry	297.0 m
Depth of Patpahar Quarry	46 m
Area of Patpahar Quarry	2999812.5 m^2
Production 2009-10	145600 MT
Stripping ratio	1: 0.048
Bench height	5m
Width of the bench	5m

Figure 3.1.2 View of Patpahar Quarry [14]

3.1.3 WASTE GENERATION IN PATPAHAR QUARRY

There are two main sources of waste generation in the Patpahar quarry these are: -

1) Mines quarry
2) Crusher

Waste from mines

The waste generated in the mines is basically the overburden. This overburden is removed to extract the dolomite from the mines.

Types of waste generated in the mines are:-

1. **Solid waste:**
    a) Soil
    b) Epidiorite and
    c) Intercalated waste
2. **Liquid waste:** Waste water from various operations.
3. **Air pollution:** Emission of particulate from loading, crushing, hauling.

Solid Waste from Mines

The waste produced from opencast limestone mining which is at present the dominant extraction for mining of mineral deposits comprise the overburden which needs to be removed during the opening up and development operations as well as during actual extraction of the deposit over the mine life. Staggering volumes of waste low in ultimate value are produced over the lifecycle of a mine posing disposal and environmental problems. Environmentally, opencast mining is more harmful than underground mining as large tracts of land on the earth are divested, though temporarily disturbing all components of neutral ecosystem.

Table 3.1.5 Ore and Waste Production of BSL Mines [14]

Dolomite	Production for 2008 – 09	Production for 2009 – 10
Ore (MT)	145600	156000
Sub-grade ore	7000	7500
Intercalated waste	7000	7500

The winning of the dolomite again needs drilling, blasting and handling of dolomite. The Mining generates some valuable constituents like soil and green mass transformed to waste material, because of mishandling drilling, blasting, crushing, sizing

Each ton of limestone or dolomite on an average is associated with the removal of 4 tons of waste rock; this mass is being shifted from mine quarry to the dumping yard.

Waste from Crusher

There are two numbers of crusher and also there is one number of Mini crusher in the Patpahar area. The crushing operation of dolomite in the crusher gives various sizes of dolomite product, using different screens. Both the crushers operating have the production capacity of 120 tons per hour.

Table 3.1.6 Details of Crusher No 4 & 5 [14]

Sl. No	Crusher	Feed material	Feed size (mm)	Output
1	SCH: 5	Dolomite	300	+25mm, -50mm, -25mm, +10mm, -10mm, +6mm
2	R.M.M	Limestone	300	+25mm, -50mm, -25mm, +10mm, -10mm, +6mm

Dolomite and limestone are sorted and bring to the crusher and sized in the crusher for the specification of user industry. After the crushing various products are obtained, ultimately fines of dolomite is also produced which can be considered as waste in the short term as they are further utilized in the long run.

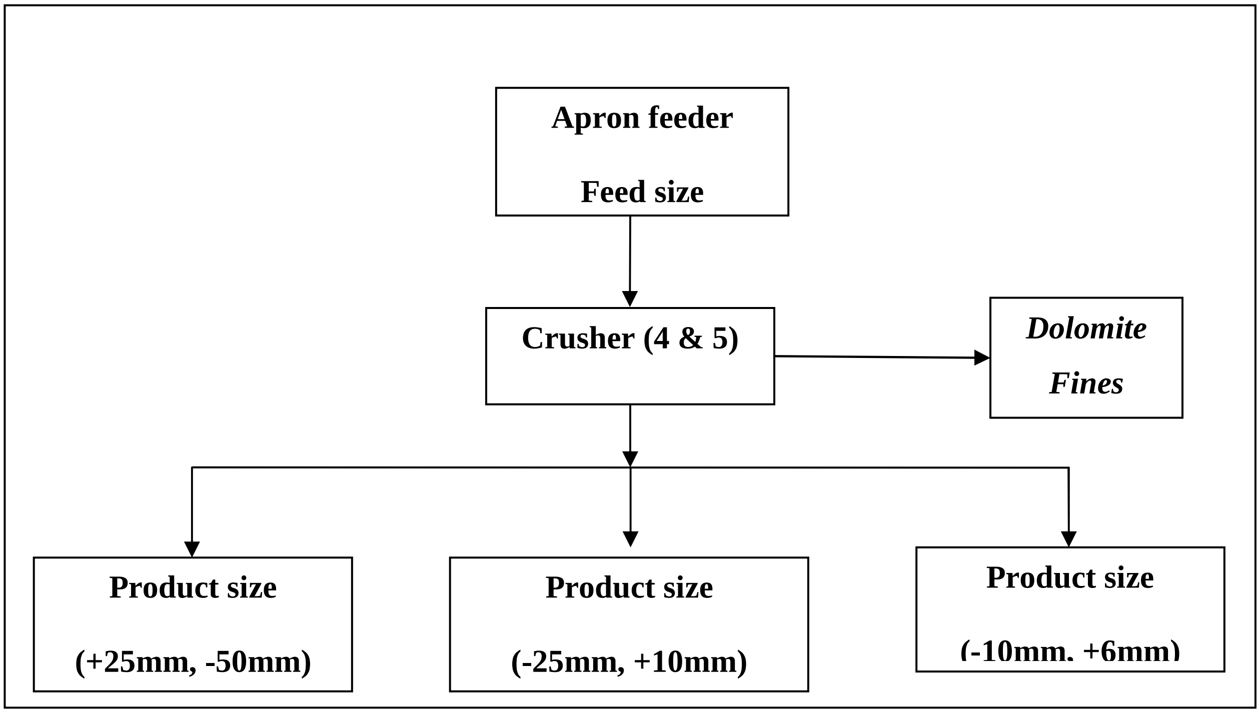

Figure 3.1.3 Flow diagram of crusher [14]

It has been estimated that the generation of solid waste generated will be at around 34,100 m^3 in the Patpahar dolomite quarry. Therefore the waste will be generated during scheme period will be: -

Table 3.1.7 Estimation Solid Waste Generation of Patpahar Quarry [14]

Sl. No.	**Year**	**Quantity (m^3)**
1	2009 – 10	7000
2	2010 – 11*	7500
3	2011 – 12*	9300
4	2012 – 13*	11300
Total		34100

Note: * Proposed value indicated for future waste generation.

Liquid waste from the mines

There is no large dam or pond or river in existing limestone mine. In the area water supply is mainly tube wells. The ground water is at 60 to 65 meters below the surface while the mining is generally carried upto 15-40m.depth. Hence there is not much problem of water pollution. Further, the ground water level is not adversely affected due to the mining activities as there is no harmful effluent from the mining activities.

Surface water effects of opencast mining and related infrastructure can be characterised as altered or diverted natural drainage lines, reduced natural runoff, concentration of runoff, mixing of clean runoff with contaminated runoff and creation of large open water bodies.

Figure 3.1.4 Waste Water of Mine [14]

Waste water is generated during various operations in the mines such as drilling, dust suppression. Mine water means any water that enters the mine and is discharged from the mine. Mine water generally comes from the washing of the dolomite in the quarry itself as they are generally in the pure form. Some of the water comes from the ground water as a spring in the mines.

Air Pollution

Air pollution from mines

Air pollution in this small limestone mine is caused from different sources of dust formation at mines as well as due to movements of trucks for transportation exploitation of limestone cause air pollution by dust particles and gases. Particles results from the disintegration and their suspension in the atmosphere causes pollution, which ultimately leads to ecological disturbances. Blasting causes noxious fumes which are harmful to health.

Figure 3.1.5 Formation of Dust during Loading [14]

Nitrogen oxides are formed during blasting of high explosives. They are also found in exhaust fumes of fuel combustion engines used in transportation

Fugitive dust is particulates of finely divided solid and liquid particles which are airborne. They form a major part of the air pollutant emissions produced from both stationary and mobile sources such as crushing, screening etc.

Air pollution from Crusher

Crushing generates particulate material highly air-borne limestone and dolomite dust in micro size. The discharge of the crusher is at a height of 10-12 m. Therefore while falling of the product especially the finer particle which is when come in contact with the air cause lots of dust in the atmosphere.

In the crusher area one can find the dolomite dust of fines scattered in the ground. Transportation of the dolomite chips or stone by the trucks and dumper from crusher contributes to the air-pollution. Even the loading and hauling process contributes to the disturbance of the fine which is settled in the ground and making them air-borne creating serious dust problem by making the environment difficult for breathing.

Figure 3.1.6 Air Pollution in the Crusher area [14]

Similarly in the mini-crusher area there the discharge height is at about 8-10m. Due the discharge height the fine of the product after processed from the crusher becomes air-borne. In case of the transportation, loading anyone can see in the atmosphere huge dust cloud.

Table 3.1.8 AAQ standards of Central Pollution [18]

Sampling area	**SPM** **(µg/m^3)**	**SO_2** **(µg/m^3)**	**NO_x** **(µg/m^3)**
Industrial	500 (24 hr) 360 (Annual average)	120 (24 hr) 80 (Annual)	120 (24 hr) 80(Annual average)
Residential area	200 (24 hr) 140 (Annual average)	80 (24 hr) 60 (Annual)	80 (24 hr) 60 (Annual average)
Sensitive area	100 (24 hr) 70 (Annual average)	30 (24 hr) 15 (Annual average l)	30 (24 hr) 15 (Annual average l)
Annual Average: Annual Arithmetic Mean of minimum 104 measurements in a year taken twice a week 24-hourly at uniform interval **24 Hours Average:** 24-hourly/8-hourly values should be met 98% of the time in a year. However 2% of the time, it may exceed but not two consecutive days.			

Table 3.1.9 AAQ data of Patpahar Mines Area [14]

Sampling area	SPM ($\mu g/m^3$) (annual average value)	SO_2 ($\mu g/m^3$) (annual average value)	NO_x ($\mu g/m^3$) (annual average value)
Mining area AAQ Standards	135.8 360	4.50 80	11.48 80
Crusher area AAQ Standards	328 360	4.00 80	17.87 80
Residential area AAQ Standards	115.7 140	3.80 60	2.60 60
Mines (Patpahar Weigh bridge) AAQ Standards	218 360	Below 4.00 80	19.17 80

Discussion

The AAQ data of the patpahar mines area has been given in the above Table 3.1.11. The result found for SPM, SO_2 and NO_x are below the AAQ standard prescribed by Central Board Control Board. Hence there is no problem of gaseous emission.

3.1.4 WASTE DISPOSAL IN THE MINES

Disposal of Solid Waste

The waste generated for the mines quarry will be dumped in two places which are:-

1) One is nearby active dump towards north of Patpahar dolomite quarry.
2) Second dump is proposed toward the southern side of Kurpani dolomite quarry.

The solid waste generated from the mines quarry i.e. overburden is disposed in the two dumps which is mentioned above. These two dumps are adjacent to the mines. The southern dump presently not in use as it is fully-filled. Further the southern dump will be cleared and then can be re-used. The northern dump is presently is in use and overburden which is generated from the mines quarry is dumped here. The details of the mines are given in the table below.

Table 3.1.10 Details of waste dumps of Patpahar Quarry [14]

Dumps	Area of dumping (hectare)	Height of dump (m)	Distance from the quarry (km)
Northern dump	4.90	5	0.5
Southern dump	4.30	5	0.75

Figure 3.1.7 Northern Dump of Patpahar Quarry [14]

Figure 3.1.8 Southern dump of Patpahar Quarry [14]

From the above table we know that the area of the northern dump is greater in comparison to the southern dump of the mines quarry. The height of the dumps which has maximum is 10m. But the mine has constantly kept the height of the dumps to about 5m.

The overburden which is dump is generally the top soil and the clay. The deposit of the dolomite is not much deep as it is found in the depth maximum of 10-20m below the ground. Therefore the dump is generally filled by the waste that is basically top-soil and clay and other similar waste.

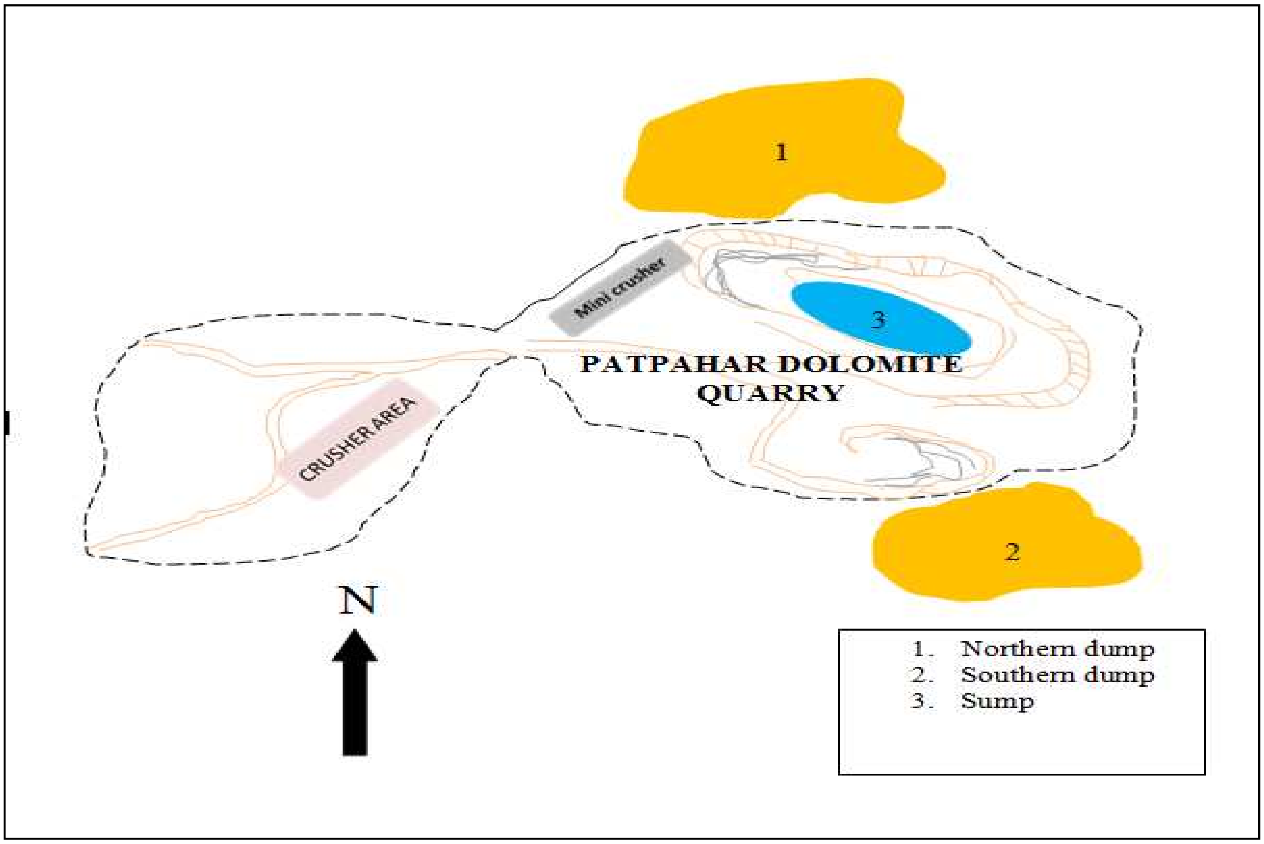

Figure 3.1.9 Layout of Patpahar Dolomite Quarry [14]

In layout of the patpahar can we can see that there are two solid waste dumps northern and the southern dump. Solid waste generated from the mine is disposed in these two dumps. Till now backfilling process is not carried out, so this waste is not being used as a backfilling material. Currently the waste which is in the dumps is being utilized for plantation and paddy harvesting.

Disposal of Liquid Waste

In this limestone mines there are no water problem. The water which is generated from the mines is directly discharged in the mines. As the quantity generation of water is very less so there is no problem of water pollution.

As the mine is small and manually operated, the waste water generated is discharged in the site itself. Further the mine waste is drained-off by making suitable drains. The drains leads the waste water to the bottom of the pit where is stored.

Figure 3.1.10 Water stored in the Sump

As the water stored in the pit bottom is below the pollution norm. So water pollution is not a big problem in the mining area.

Soil Analysis

The soil sample was collected from the mines and it was tested

Sampling: Soil was taken from the waste dump of the mine.

Analysis of soil: Soil taken from the mines was tested with Field Soil Testing Kit

Model: Orlab soil testing kit.

Soil analysis was done in the lab and the results obtained are given in the Table below:

Table 3.1.11 Soil analysis data of BSL Mines

Sl. No	Test	Rating
1	pH	6 (medium)
2	Organic Carbon	0.3 % (low)
3	Soil Nitrate Nitrogen (NO_3- N)	210 Kg/Hec (low range)
4	Soil Ammonical Nitrogen (NH_4- N)	17 Kg/Hec
5	Phosphorous (P_2O_5)	30 Kg/Hec
6	Ca + Mg	60 meq/100gm
7	Sulphur (SO_4 –S)	15 ppm
8	Potassium as K_2O	180 Kg/Hec (medium)
9	Potassium as K	33.65 Kg/Hec
10	Calcium as Ca	40 meq/100gm
11	Magnesium as Mg	20 meq/100gm

Result of soil analysis

The different parameters of the collected soil sample were analyzed and are presented in the Table 3.1.10. It may be observed that the pH value is slightly acidic. Organic carbon content in the soil is low. Similarly Soil Nitrate Nitrogen content in the soil is also low. The parameters like Soil Ammonical Nitrogen (NH_4- N), Phosphorous (P_2O_5), (Ca & Mg), Sulphur (SO_4 –S), Potassium as K_2O are in medium concentration.

Discussion

The survey of the soil quality is important and of great concern as because of it pollution levels as it affect the vegetation and growth of the plants. Further the soil can be used for reclamation purpose so it was important to assess the quality of the soil. The value obtained from the testing of the soil shows that the soil can be used for the reclamation. Soil should be treated with nitrogen rich fertilizer to bring back the quality of the soil before reclamation.

Water sample analysis

Water sample collected from the mines and analyzed.

Sampling: - Water sample was collected from the sump of the mines.

Analysis of soil: Water sample taken from the mines was tested with Field Water Testing Kit.

Model of the Kit: Orlab Water Testing Kit.

Water analysis was done in the lab and the results obtained are given in the Table below:

Table 3.1.12 Water analysis of BSL Mine Water

Sl. No	Parameter	Mine Water	Permissible Limit (IS: 10500-1991)
1	pH Value	7.52	5.50-9.00
2	Odour	Unobjectionable	-
3	Total hardness (as $CaCO_3$), mg/l	118.5	600
4	Iron (as Fe), mg/l	0.05	1.0
5	Chloride (as Cl), mg/l	60	1000.00
6	Residual Chlorine, mg/l	Nil	1
7	Total alkalinity, mg/l	178	200

8	Calcium (as Ca), mg/l	47.4	200
9	Calcium (as $CaCO_3$), mg/l	118.5	600
10	Magnesium (as Mg), mg/l	276.08	100
11	Ammonia, mg/l	2.4	1.2
12	Phosphate, mg/l	0.0156	5
13	Sulphate, mg/l	Below 40	400

Result

The result obtained from the analysis of the water was that the pH level of the water was appropriate as per norms. Similarly Iron (as Fe), Chloride (as Cl), Total alkalinity, Calcium, Phosphate, Sulphate was found to be below tolerance limit. Magnesium and Ammonia concentration in the water was found to be excess and both concentration are above the norm.

Discussion

The analysis of the water is of great concern because of its high potential toxicity to the various biological forms. Magnesium and other alkali earth metals are responsible for water hardness. So the concentration of magnesium is higher so the water is hard water. Ammonia is extremely toxic and even relatively low levels pose a threat to fish health. Since the level of ammonia is high the water tested is toxic.

3.1.5 WASTE MANAGEMENT IN THE MINES

Solid waste management

The solid waste generated from the mines is used for:

1) Plantation as the top-soil is beneficial of the growth of the plants.
2) Used in agricultural land, the pockets of loamy soil is suitable for paddy harvesting.
3) Land filling.

Management of crusher waste

The waste which is generated from the crusher i.e. the dolomite fines generated is temporarily is considered to be waste. These fine generated is further utilized as a flux in the steel plant. It is used in the sintering plant for making suitable flux.

Liquid waste management

The liquid waste can be managed by the following:

a) Settling or treatment pond before discharge to the water sources.
b) The water present in the mine sump is reused in the mines for dust suppression measures.

Depending upon the nature of pollutant, the process could be settling or filtering for physical treatment of chemical pollutant and quality improvement by biological means. The waste materials in the water body are the following:-

- Leaching and mixing: calcium and magnesium salt making water hard.
- Oil, Grease, mixing: from machine, tar product.

Formation of garland drain, diversion of drain and rivulets and maintenance of favorable gradient of dumps are some of the physical means to minimize water pollution. Leaching erosion of the dumps can be binding grass, plantation, terrace formation or carpeting.

Water management by way of forming water pools and lagoons in the void area or dumps serves as settling pond and meet the requirement of the flora and fauna. The damaging impact of the surface mining in form of lowering water table of the region, loss of portable water, loss in the soil moisture etc. could be taken care of by water management, which otherwise could be a pollutant of the surface water streams. The water pool could be used for the fish culture after water treatment, eradication of weeds and amendment of water body and stocking of the pond.

Water Pollution Control Management

The following management techniques are proposed for the effective control of water pollution:

- ❖ Suitable drainage system will be provided to prevent surface water from entering into mines directly, to reduce soil wash off.
- ❖ Sufficient number of retaining walls/Check walls will be provided to OB dump and other areas in order to avoid the soil wash out

Management of Particulate Material

The mining area of the Patpahar area is greatly facing air pollution from particulate emission, similarly is the situation in the Patpahar crusher area.

The gaseous discharge to a great extent can be controlled or minimized by proper maintenance of operating machines; control and maintenance of mine haul road and dumps. The transport system should be streamlined by the use of electricity operated machines. The dust suppression is possible by proper layout of haul road including water sprinkling dust extractor at the transfer points, on crushing and conveyor system, dust system, dust extractor unit on blast hole drills, and hoods on all transfer points and conveyors.

In Patpahar quarry special explosive is used in the blasting. Explosive used has special characteristics that after charging, the blasting occurs with making less sound and there are lesser fumes. So, regarding blasting practices there is less air pollution.

3.2 WASTE MANAGEMENT IN BASUNDHARA OPEN CAST MINE, MCL

3.2.1 Introduction

Basundhara (West) OCP mine is located in north-central part of Ib Valley coalfield, which started operation during 2003-04. The project or mining lease covers an area of 401.10 ha.

Location

The project is located in the north-west of Basundhara East block and east of Chaturdhara block of Ib Valley coalfield in Sundargarh district of Orissa. It falls within:-

- Latitude: - 22^{O} 03' 32" & 22^{O} 04' 11" (N) and
- Longitude: - 83^{O} 42' 18" & 83^{O} 44' 08" (E).

Communication

The block under reference is well connected by road. It is accessible by an all weather black topped road from district headquarter, Sundargarh, located about 48 km.

Topography

The topography of the block is generally flat. The general slope is towards south. The surface elevation of the block varies from 262 m to 288 m above MSL. Main drainage of the area is controlled by the perennial Basundhara River demarcating western and part of southern boundaries of the block and its feeder streams.

Geology

There are two coal seams (Ib seam & Rampur seam) which is in the process of extraction. The grade of coal is F (Avg.). The mineable reserve is 25.32 million tons (as on 01.03.2010).

Targeted output

The project has a production of 6.0 Million Tons/Year. The overall stripping ratio works out to be 0.81 cum/t.

Life of the mine

The life of the mine has been estimated to be 4 years from 01.04.2009.

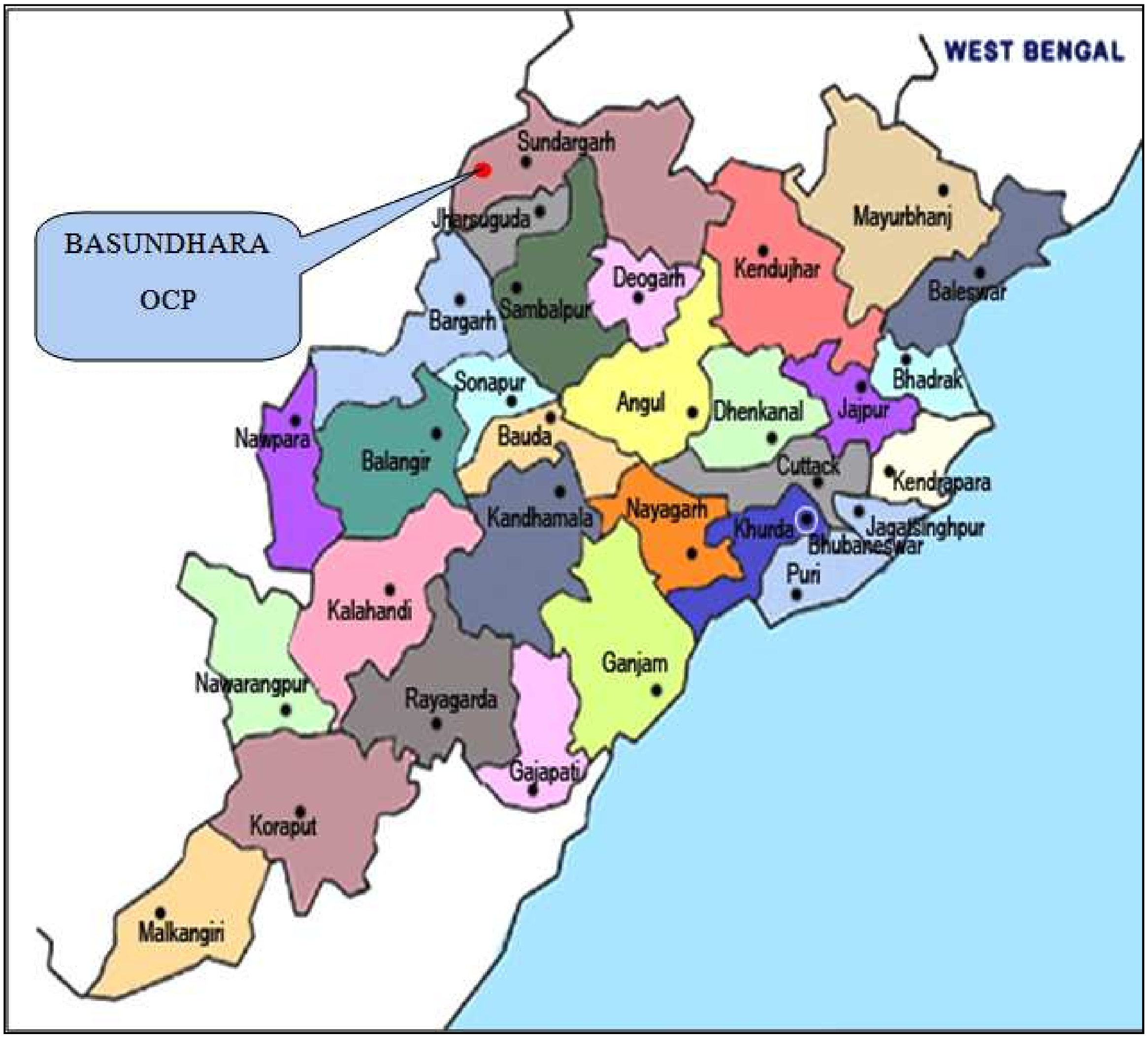

Figure 3.2.1. Location of Basundhara Mines

Manpower the mines

Manpower requirement for this project is 603 including existing manpower of 447 persons.

Mining technology

Shovel-dumper system is being used for overburden removal. Coal extraction by surface miner technology (blast free mining) and conventional drilling & blasting with shovel dumper system.

Coal wining, OB removal and transportation

About 40% of total coal production shall be excavated by drilling & blasting with shovel dumper system. Blasted coal is loaded by shovel on to dumpers and transported upto receiving pit of feeder breaker. Balance 60% coal output shall be excavated by surface miner. Part of production is being dispatched to small customers through road and rest is being dispatched by rail.

Coal handling

The coal handling plant of Basundhara (West) OCP will handle an output of about 3.0 MT per year of ROM coal produced through conventional drilling / blasting. Balance coal shall be excavated by blast free mining (by surface miner) with (-) 100 mm size. The ROM coal is expected to have lump size upto 1200mm, which will be crushed by feeder breakers to (-) 200mm size.

Figure 3.2.2. View of Basundhara Mines

3.2.2 WASTE GENERATION IN BASUNDHARA (WEST) OPENCAST MINES

There are three main sources of waste generation in the Basundhara west opencast mines these are: -

3) Mines quarry
4) Workshop

5) Overburden Dump

Waste from mines

The waste generated in the mines is basically the overburden. This overburden is removed to extract the coal from the mines. The different types of waste generated from the mines are as follows:-

1. **Solid waste:** Soil & OB.
2. **Liquid waste:** Waste water from various operations.
3. **Gaseous waste:** Emission of particulate from loading, crushing, hauling.

Solid Waste from Mines

The waste produced from opencast mining which is at present the extraction for mining of mineral deposits comprise the overburden which needs to be removed during the opening up and development operations as well as during actual extraction of the deposit over the mine life. In Basundhara Opencast mines the deposit of the coal in found in the shallow depth, even outcrop of the coal deposit in some where present in the surface of the land. Therefore the thickness of the overburden above the coal is not very much. So the generation of the overburden in the mines compared to the coal is not very much.

Environmentally, opencast mining is more harmful than underground mining as large tracts of land on the earth are divested, though temporarily disturbing all components of neutral ecosystem.

The winning of the coal again needs drilling, blasting and handling of coal. The Mining generates some valuable constituents like soil and green mass transformed to waste material, because of mishandling drilling, blasting, crushing, sizing. Production of coal and overburden is given in the Table 3.2.1.

Table 3.2.1 Production of Coal Vs overburden [15]

Month	Production of coal in 2009-10 (tons)	Production of in overburden 2009-10 in (m^3)
April	640588.2	199530
may	629351.92	200646
June	568193.90	199470
July	453671.06	1448574
August	425990.98	137760
September	437636.95	138327
October	520722.99	130512
November	580102.55	137130
December	614877.32	148075
January	598216.33	134250
February	556562.60	138555
March	642295.58	155370

Each ton of coal on an average is associated with the removal of 2 tons waste rock is removal. The overburden generated from the mines is directly disposed in the external dump of the mines.

Liquid waste from the mines

Water in the mines is collected in the bottommost part of the mines. Used water of the mines, rainwater, water seepage all goes to the sump. This water which is collected in the sump has to be removed so that the coal in the particular area to be exposed. Further, coal is exposed after the removal of water and then coal is extracted. The water which is in the sump is temporarily stored; sump water with the help of Pump is drained out and is transferred to different place.

Figure 3.2.3 Sump area of the mines

Water transferred is disposed to abandon mine which is nearby. Further water is disposed in the natural water source or nullah so as to minimize the impact of water on the environment.

Waste water from mine

Open pit mining sometimes intercepts highly permeable zones, with resulting high inflows of water into the excavation area. This remains a major problem in the west Basundhara opencast mines. The water which is collected in the mines is stored in the sump of the mine. The water which is stored in the sump has to be removed so as to expose the coal. In these mines the water which is stored in the mines is dewatered through the pumping system. The pump transfers the mine water through pipeline to another area. This area where the water is transferred is de-coaled area; it is an abandoned mine, earlier known as East Basundhara open cast mines.

The flow diagram for the mine water to be disposed is given in the figure below. In there, first of all water that is present in the mine is through pump is dewatered and is transferred to the abandoned mines. Due to the time variation as it is a vast land area it requires time to fill the de-coaled area. Therefore due to natural process sedimentation of the water takes place. Finally there takes place separation of mine water from the sediments, which ultimately give clear water

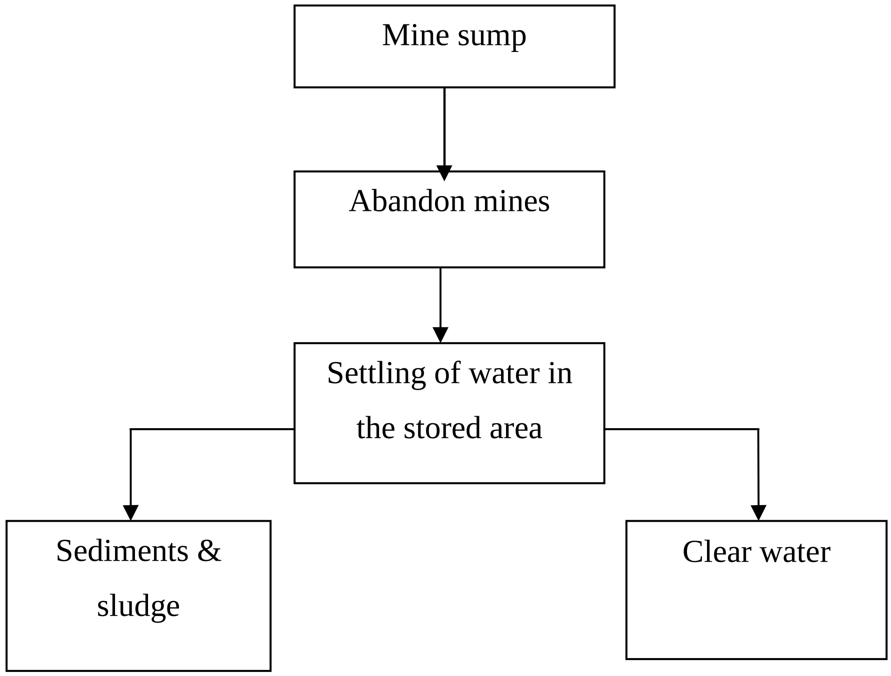

Figure 3.2.4 Flow diagram for Separation of Waste Water from the Mines [15]

Waste water from the workshop

Mine effluent treatment plant is constructed in the mines the water is treated here and circulates back for washing purpose. Mine effluent is from the mines are stored in the de-coaled void and there is no need for further treatment. Deployment of heavy earth moving machineries (HEMM) is required for carrying out the various mining operations. These HEMMs are brought to the workshop for the purpose of washing and repairs. During washing operations, the suspended solids as well as some oil and grease are mixed into the water and they are led outside the workshop.

The workshop effluent is thus, generated by washing of HEMMs like dumpers, grader, dozers and pay-loaders etc. and floor/road washings. The effluent is mainly contaminated with silt, suspended solids and oil and grease. Workshop Effluent Treatment Plant (WETPs) has been constructed in mines for separation of free oil and grease in the oil and grease trap. WETP consist of pre-sediment tank, chemical house, flash mixer, secondary tank and pump house for re-circulation of the treated water.

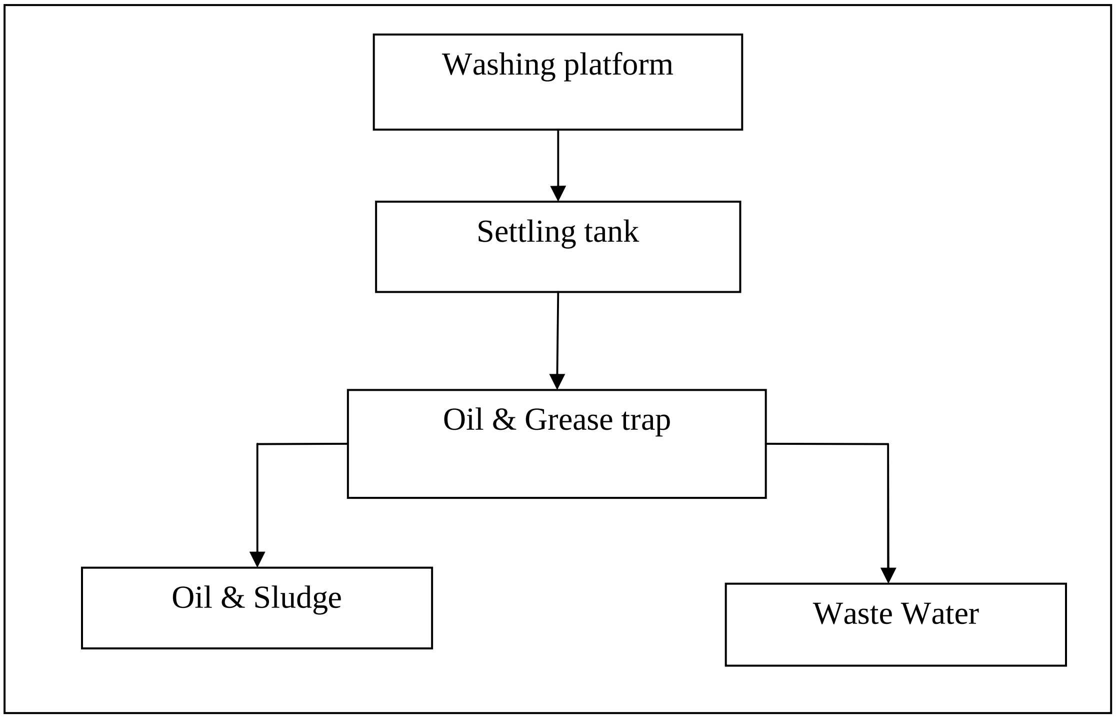

Figure 3.2.5 Flow diagram of Waste water separation from the Oil & Grease trap [15]

Figure 3.2.6 Oil & Grease trap in the workshop [15]

The water which is obtained by the process is directly disposed in the nullah of the mine and it is never reused for any other purpose.

The oil and grease which is finally obtained is collected and stored in the workshop. The grease and oil obtained is finally sold to private parties.

Table 3.2.2 Generation data of Grease & Oil [15]

Generating material	Quantity generated	Management of the material
Grease & Oil	2 barrel/year	Sold to private parties

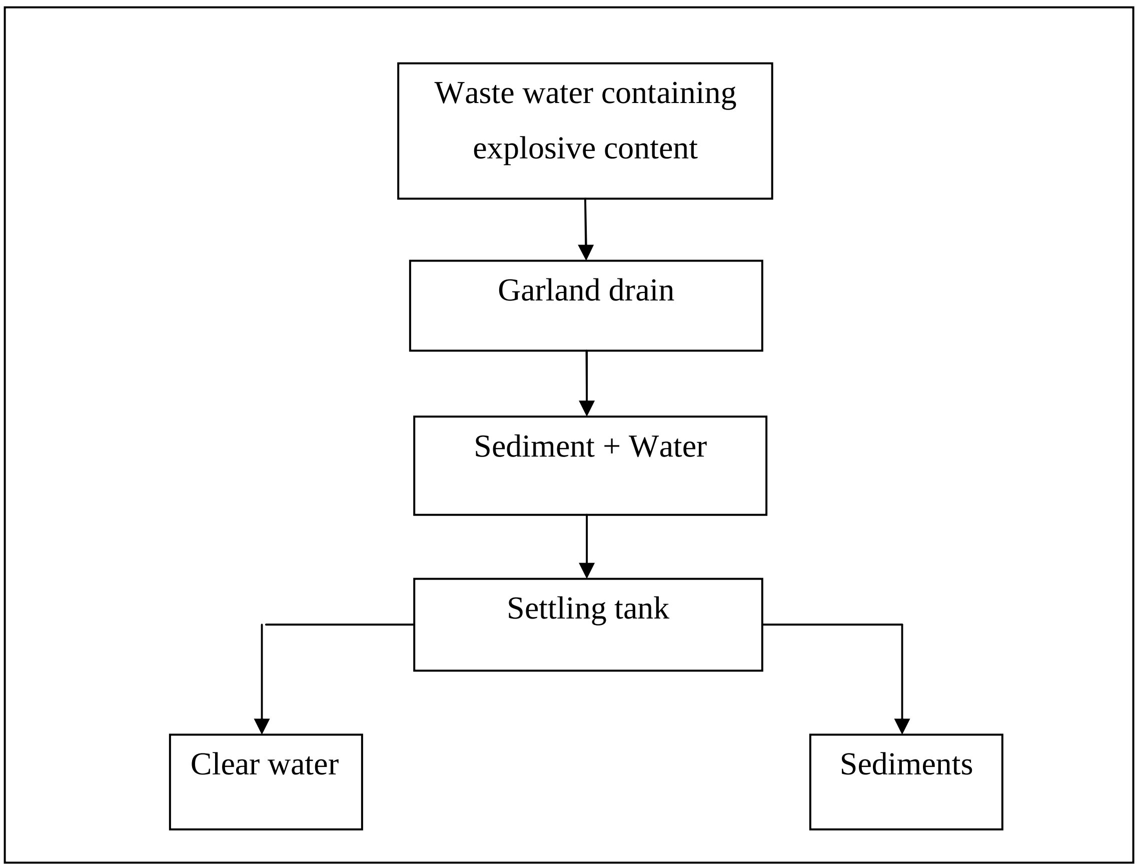

Figure 3.2.7 Flow diagram of Water Separation from Waste Dump [15]

Air pollution from mines

Air pollution in this mine is caused from different sources of dust formation at mines as well as due to movements of trucks for transportation exploitation of coal cause air pollution by dust particles and gases. Particles results from the disintegration and their suspension in the atmosphere causes pollution, which ultimately leads to ecological disturbances. Blasting causes noxious fumes which are harmful to health.

Nitrogen oxides are formed during blasting of high explosives. They are also found in exhaust fumes of fuel combustion engines used in transportation

Fugitive dust is particulates of finely divided solid and liquid particles which are airborne. They form a major part of the air pollutant emissions produced from both stationary and mobile sources such as crushing, screening etc.

3.2.3 Waste Disposal in Basundhara Mines

Disposal of Solid Waste

The waste generated for the mines quarry will be dumped in two places which are:-

1. External dump
2. Internal dump

The solid waste generated from the mines quarry i.e. overburden is disposed in the two dumps which is mentioned below. These two dumps are adjacent to the mines. The external dump is adjacent to the mines and the internal dump is basically used in the mines which means it is used for back-filling area of the mines

Table 3.2.3 Details of Waste Dumps of Basundhara Mines [15]

Dumps	Area of dumping (hectare)	Height of dump (m)	Distance from the face (m)
External dump	11.37	20	200
Internal dump	6.30	25	100

The overburden which is dump is generally the top soil and the clay. The deposit of the coal is not much deep as it is found in the depth maximum of 10-20m below the ground. Therefore the dump is generally filled by the waste that is basically top-soil and clay and other similar waste.

Figure 3.2.8 Internal Dump of Basundhara Mines

Figure 3.2.9 External Dump of Basundhara Mines

In the mines Internal dump which is used is other word we can say that it is used for mine reclamation purpose. Solid waste is which generated from the mine is directly dump in these dumps. Further technical reclamation is carried out by the use bulldozers and other machineries.

Presently dumping is not carried out in the external dump. It was used at the starting of the mine to access the coal deposit. The external dump which is now present in the mines is now biologically reclaimed. Plant saplings have been planted on the upper surface of dump, which is first done by spreading loamy soil as per norms.

In layout of the mines we can see two solid waste dumps, external and internal dumps. Solid waste generated from the mine use as a backfilling in the mine. In the figure dumps No1 is the external dump and the dump No.2 is internal dumps which is being used for backfilling the mines. Presently the eastern part of the Basundhara (west) open cast mines is being used as an internal dump as the extraction of the coal has already been carried out. In the eastern side of the mines is Basundhara (east) mine which is an abandoned mine. Half part of this mine has been backfilled and half is utilized as water reservoir. Mine waste water that is generating from the mines is taken or pumped to this area to store it. Further the water stored is utilized for various purposes.

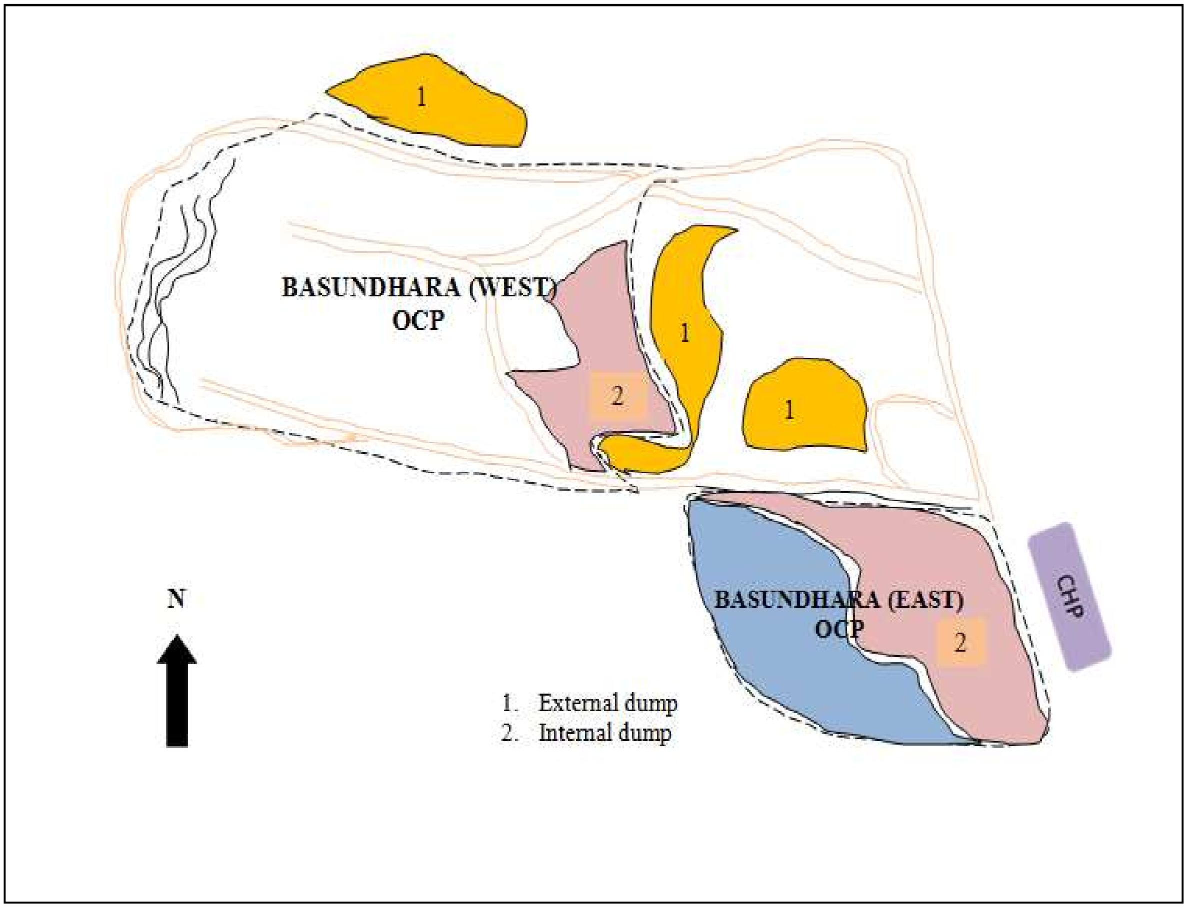

Figure 3.2.10 Location of Basundhara OCP [15]

Disposal of Liquid Waste

In this mine there are no water problems. The water which is generated from the mines is directly discharged in other abandoned mines i.e. East Basundhara Mines. Coal from this mine is extracted now it has been partial backfilled and partially it is used as water reservoir of the Basundhara West mines.

Figure 3.2.11 East Basundhara Mines [15]

Whatever water that is produces in the mines is dewatered by the help of pump and it is transferred to another area. The area where waste water is taken is an abandoned mine. This abandoned mines is known as Basundhara (East) mine, since the area is large it takes time to filling. After filling of this land with water, there is an arrangement made that it will discharge the clear water to the nullah. The nullah is attached to the abandoned mines. The sediment of or sludge which is ultimately settled at the bottom will not come out and in this way water is discharged in the environment.

Soil Analysis of the mine

The soil sample was collected from the mines dump and it was tested

Sampling: Soil was taken from the mines. Soil taken was Top-soil near to the external dump

Analysis of soil: Soil taken from the mines was tested with Field Soil Testing Kit.

Model: Orlab soil testing kit.

Water analysis was done in the lab and the results obtained are given in the Table below:

Table 3.2.4 Soil analysis data of Basundhara Mines

Sl. No	Parameter	Rating
1	pH	6.5
2	Organic Carbon	0.3%(low)
3	Soil Nitrate Nitrogen (NO_3- N)	150 Kg/Hec(low)
4	Soil Ammonical Nitrogen (NH_4- N)	34 Kg/Hec
5	Phosphorous as (P_2O_5)	35 Kg/Hec
6	Calcium & Magnesium (Ca + Mg)	40 meq/100gm
7	Sulphur	44.80 Kg/Hec
8	Potassium as (K)	195 Kg/Hec
9	Potassium as (K_2O)	265 Kg/Hec
10	Calcium	15 meq/100gm
11	Magnesium	25 meq/100gm

Result

The different parameters of the collected soil sample were analyzed and are presented in the table 3.2.4. It may be observed that the pH value is slightly acidic. Organic carbon content in the soil is low. Similarly Soil Nitrate Nitrogen content in the soil is also low. The parameters like Soil Ammonical Nitrogen (NH_4- N), Phosphorous (P_2O_5), (Ca & Mg), Sulphur (SO_4–S), Potassium as K_2O is well present in the soil, and they are almost medium in concentration.

Discussion

The result from the analysis of the soil was that the concentration of the organic carbon and the soil nitrogen content found was below the desirable limit. All the other parameters found was appropriate. Further the soil can be used for reclamation purpose. But the soil should be treated with fertilizer to regain its nitrogen and organic carbon before the reclamation process.

3.2.4 WASTE MANAGEMENT IN THE MINES

Solid Waste Management

The solid waste generated from the mines is used for:

a) Plantation as the top-soil is beneficial of the growth of the plants.
b) Used in agricultural land, the pockets of loamy soil is suitable for paddy harvesting.
c) Land filling.

Control measures

Attempt has been made to minimize the land requirement for the project. Various measures which have been taken into account are as follows:-

1. Diversion of forest land for mining and its associated activities has been restricted to the minimum as far as possible.
2. Sound land resource management is being followed.
3. The backfilled area will be reclaimed both technically and biologically.
4. Proper reshaping of dumps and drainage arrangement for precipitation runoff are being done.
5. The topsoil is progressively and concurrently utilized during physical/technical reclamation of the backfilled area.

Waste Dumps

During rainy season there is run-off water which carries soil from the water dumps i.e. External dump. The dumps water is hazardous as it contains explosive particle which come after the blasting, during the process of removal of overburden from the mines.

Control measures

1. Drains will be made on the dump top to regulate uncontrolled descent of water during rainy season down the slope through specially made chutes to finally discharge into garland drains.
2. Plantation along the periphery of dump top. Small pits of 0.3 x 0.3 x 0.3 m will be cut on dump slopes and seedlings will be planted to prevent erosion stabilize dump slopes.
3. A stone toe wall will be constructed all around the waste dump base to prevent waste dump material being carried out to the general drainage system of the area.
4. A garland drain will be constructed all around the waste dump area for smooth flow of water.
5. Dump slopes will be kept at $< 26^0$ considering the optimum bench height.

Liquid Waste Management

The liquid waste can be managed by the following:

a. At the generation stage,
b. During drainage or pumping stage.

Water that is generated from the mines is taken to settling or treatment pond before discharge to the water sources with the help of sufficient number of pumping and drainage arrangement for dewatering of mine.

Control measures

1. In Basundhara OC project, suitable mitigatory measures are being/will be taken to minimize the impact on surface water sources by realignment/re-coursing of the drainages in the core zone for avoiding flooding, siltation, choking and pollution of water sources.
2. The continuity of aquifers in the excavation area is being/will be restored to the extent possible by backfilling of de-coaled area.
3. The final left-out void will act as conduits for recharging the aquifers.
4. Recycling of wastewater at some sources after appropriate treatment to achieve **"zero discharge"** to the extent possible.
5. Conforming to the limits of the Environment (Protection) Amendment Rules, 2000 ("Schedule-VI", General Standards for discharge of environmental pollutants, Part-A: Effluents) for the quality of the treated effluents.

The water which the mine authority ultimately disposing in the abandoned mine is further utilized. The water which is stored in the de-coaled area is use for different purposes which are:-

1. Sprinkling of water for haul road dust separation.
2. For fire fighting in the mines.

Management of Particulate Material

The mining area of the Basundhara mines is greatly facing air pollution from particulate emission. The gaseous discharge to a great extent can be controlled or minimized by proper maintenance of operating machines; control and maintenance of mine haul road and dumps. The transport system should be streamlined by the use of electricity operated machines. The dust suppression is possible by proper layout of haul road including water sprinkling dust extractor at the transfer points, on crushing and conveyor system, dust system, dust extractor unit on blast hole drills, and hoods on all transfer points and conveyors.

Air quality control measures

Ambient air quality will is affected due to presence of RPM, SPM, SO_2 and NO_X which are generated due to various activities in the mines. Appropriate air control measures are being adopted and will be adopted to maintain the ambient air quality within the stipulated standard. The control measures will be adopted for various operations like drilling operation, blasting operation, loading and transport, coal handling plant, fires at coalfaces and coal stock yard, OB dump(s) and workshop and stores, etc. The measures which are taken by the mines are as follows:-

1) Dust extractor in drill machines, 3 nos. of drill has been equipped with dust extractors. Additional 1 nos. of drill will be provided with dust extractor.
2) Fixed sprinkler at CHP, for haul road 100 nos. additional 50 nos. of sprinkler will be installed.
3) Mobil water sprinkler for haul roads, transportation 50 nos. of fixed sprinkler will be installed.
4) Cleaning/sweeping of dust from coal transportation road Manual Mechanical sweeper is proposed.

3.3 WASTE MANAGEMENT IN HIRAKHAND BUNDIA UNDERGROUND COAL MINE

3.3.1 Introduction

Location

Hirakhand Bundia U/G Mine is located in Orient area of Ib Valley coalfield. The nearest town is Brajrajnagar. The state highway passes at a distance of 10 km from the project. The nearest rail head on Howrah- Mumbai main line of South Eastern Railways is Brajrajnagar which is about 4 km from the block. Jharsuguda – the district headquarter is about 16 km. away from the area and is well connected by all season motor able road. Sambalpur - headquarter of Mahanadi Coalfield is about 70 km. away from the block and is well connected by rail and road (NH 200 & NH-10).

It falls within the

- Latitude: - 20^{O} 48’ 45” & 21^{O} 48’ 30” N and
- Longitude: - 83^{O} 54’ 00” & 83^{O} 56’ 00” E.

Topography & drainage

The area is characterized by undulating topography with general slope towards Ib River which flows from north to south. The average elevation of the area is about 30 m from mean sea level. Lilari nullah flows in the south. The drainage system of the area is mainly controlled by Ib River which flows from north to south towards the eastern part of the block.

Geology

There are three seams viz. Lajkura, Rampur and Ib seams. Rampur seam (4 sections) and Ib seam (middle section) are being extracted in this mine. The grade of coal is ‘D’. The mineable reserves are 28.245 Mt for HR seam and 6.310 Mt for Ib Middle seam.

Mining technology

Coal is exploited by mechanized bord and pillar method using LHD with roof stitching and bolting. However, there is proposal for deployment of continuous minor for the incremental production.

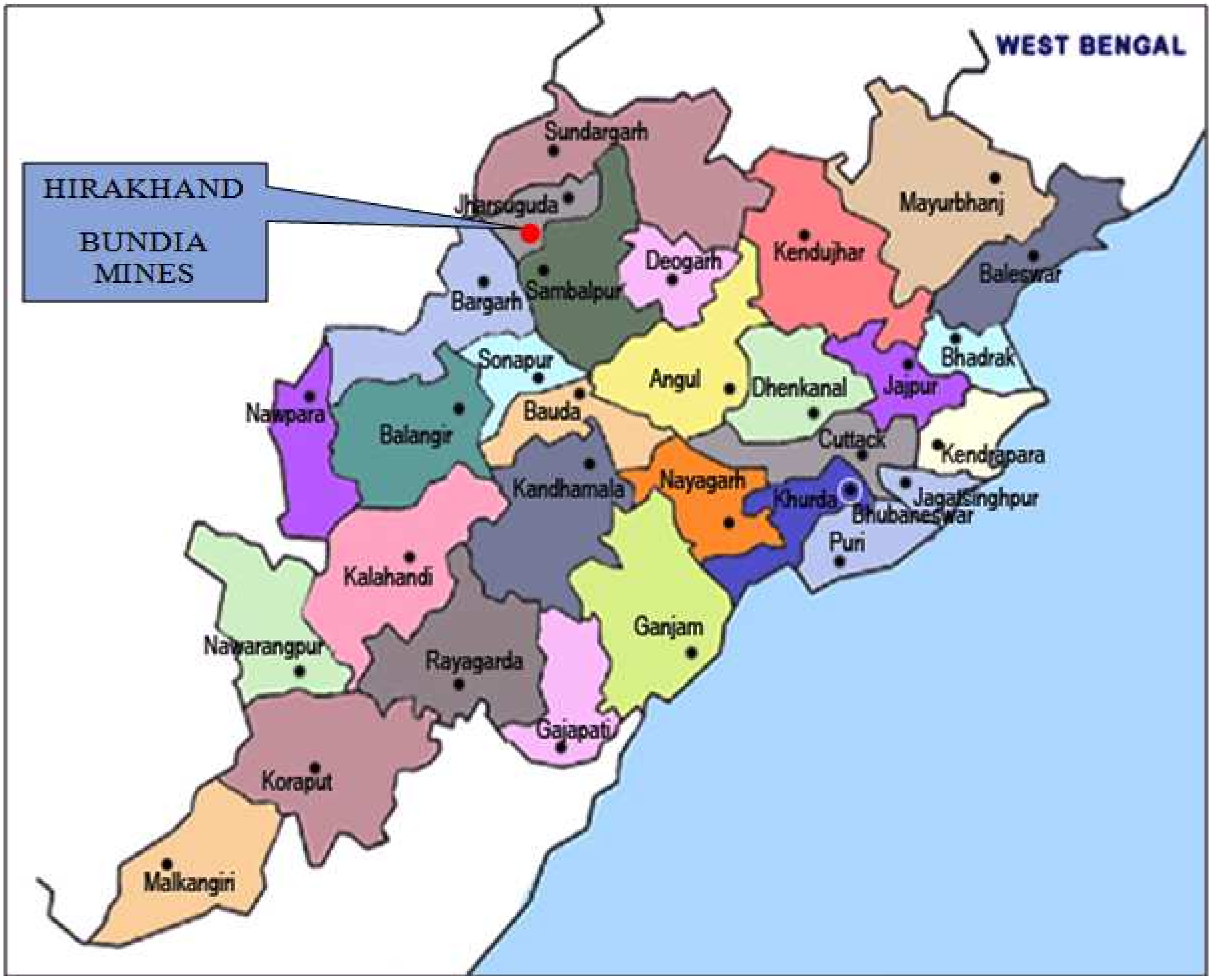

Figure 3.3.1 Location of Hirakhand Bundia Mines

Coal winning and transportation

Coal from the face is loaded by LHDs on the pony belt conveyor which transfers coal to the gate belt conveyor. The gate belt conveyor transports coal out of the district and loads on to the trunk belt conveyor in 1 DN in the main dip. Incline No.2, where it transfers coal to main belt conveyor installed in the incline. The main belt carries coal to the surface bunker (2 x 75 tons) for truck loading. The coal from the surface bunker is loaded into 16 tons capacity trucks and transported to railway siding which is at a distance of 8 km.

Output of the mines

The project will have a targeted sustained output of 0.95 million ton per year with Continuous miner.

Life of the mine

The balance life of the mine has been estimated to be 26 years.

Manpower

The existing manpower of the mine is 986. No additional manpower is required for the augmentation of the production.

Coal handling & dispatch arrangement

The blasted coal is loaded into belt conveyor by LHD. The gate belt feeds to trunk belt installed in main dip up to surface bunker. Coal is loaded into the trucks of 16 t capacity from bunker and transported to Orient railway siding by double lane black topped road [16].

Main consumer

Coal from this project will meet the demand of Rourkela Steel Plan and Power Houses of Tamil Nadu State Electricity Board.

Project Profile

(a) Project Boundary

North: - Himgir-Rampur colliery and Unit-2 of Brajrajnagar lies in the northern side of the mine.

East: - V.S.S. Nagar and Telen Kacchar basti are located adjustment to eastern boundary.

South: - Ainlapali, Kantatikira and Budhihali villages are on southern side of area.

West: - Samaleswari OCP and Chingriguda village are on western side of the mine.

(b) Distance From Water Bodies

In the Table 3.3.1 it gives the distance of the water bodies near to the mines water. These bodies source are river, nullah and water reservoir.

Table 3.3.1 Water Bodies Near To the Mines

Distance from	River bank	other water bodies sea/creek/lake/nullah, etc. (specify)
Mining lease boundary	1. Ib River 2. Lilari nullah 3. Bagachhara nullah 4. Hirakud reservoir	2.0 km 2.5 km 2.4 km 10.0 km

Figure 3.3.2 Aerial view of Hirakhand Mines (www.googleearth.com)

3.3.2 WASTE GENERATION OF HIRAKHAND BUNDIA MINES

Hirakud Bundia mines is an underground coal mines. Wastes generated in the mines are basically of two types these are: -

1. Gaseous waste
2. Liquid waste.

Gaseous waste

The gaseous waste product during the coal mining has been recognized by the miners as: -

a. Firedamp (methane) -Methane is not poisonous but explosive in nature with the concentration from 5.5-15%. Since the grade of coal is low, therefore the methane produce is in very less in quantity and can be easily diluted by proper ventilating air current. Early miners prepared suicide squadron to take care of this menace. There is no danger of the methane Hirakud Bundia Mines.

b. Carbon monoxide: - This is another waste product generated due to oxidation of coal in confinement environment is CO, which is known as White damp. This is highly poisonous and generated by spontaneous heating of coal. This is also regarded as one of the green house gases, responsible for global warming. The CO, which is known as black-damp is generated with slow oxidation of coal in the sealed grooves. Due to failure of stopping many a time it flooded the mine. Through poisonous in character, it dilutes mine environment and reduce oxygen causing asphyxiation in confined environment. But still the level of hazard of the carbon monoxide is below and also there is no such danger of this gas in this mine.

c. Nitrogen Oxide: - Blasting is the main cause of the production of nitrogen fumes in the underground mines of the Hirakud Bundia mines.

d. Particulate matter: - In the mine due to various operation of stationary as well as operation of the mobile machinery, emission of the particulate matter occurs. These are generated at the time of movement of the L.H.D, Conveyors and at the time of loading and unloading of the coal in the mines.

The haul roadways of the mines is not properly maintained, one can see that the dust there is scattered in very large quantity. Further the ventilating current can to cause the dust to be air-borne and can produce dusty atmosphere. Movement of the machinery to causes the dust to be air borne.

In the Hirakud Bundia mines we can now conclude that the Air pollution in coal mines is mainly due to the fugitive emission of particulate matter and gases including methane (CH_4), sulfur dioxide (SO_2) and oxides of nitrogen (NO_x). The use of explosives releases carbon monoxide (CO), which poses a health risk for mine workers. Dust and coal particles stirred up during the mining process, as well as the soot released during coal transport, can cause severe and potentially deadly respiratory problems. The mining operations like drilling, blasting, movement of the heavy earth moving machinery on haul roads, collection, transportation and handling of coal, screening, sizing and segregation units are the major sources of emissions and air pollution. Under-ground mine fire is also a major source of air pollution in some of the coal fields.

High levels of suspended particulate matter increase respiratory diseases such as chronic bronchitis and asthma cases while gaseous emissions contribute towards global warming besides causing health hazards to the exposed population.

Methane emission from coal mining depends on the mining methods, depth of coal mining, coal quality and entrapped gas content in coal seams.

Liquid waste from the mines

Wastewater includes mine waters. Mine water means any water that enters the mine and is discharged from the mine. In Hirakhand Bundia Mines the liquid waste is the waste that is generated from the water that has been used for the purpose of dust suppression measure in the haulage road as well as in the conveyor belt sprinkling.

During drilling and site preparation for the blasting water is needed for controlling of the dust. It is to be noted that the water used in the mines is mostly required for suppression of dust in the mines. The major source of water pollution in the coal mines is the carryover of the suspended solids in the drainage system of the mine sump water and storm water drainage.

Table 3.3.2 Liquid Effluents from Coal Mining (milligrams per liter, except for pH) [16]

pH	6–9
TSS	50
Oil and grease	10
Iron	3.5
Total metals	10

Liquid waste which is generated from the mines is pumped from the mines from different levels and taken to the sumps present inside the mines. Further the liquid waste is pumped to the surface and treated.

3.3.3 WASTE MANAGEMENT IN HIRAKUD BUNDIA MINES

Gaseous waste management

The gaseous wastes generated in the mines are managed efficiently. The gaseous wastes which are tackled are as follows:-

1. Firedamp (methane):- Hirakhand Bundia mines produces low grade of coal. The grade of coal that is mined out is of D grade. Therefore the emission of the methane in the ambient air is negligible. Whatever is generated is easily diluted by the ventilating air current. Therefore firedamp is not a big problem in the mines.
2. Carbon monoxide: - This is highly poisonous and generated by spontaneous heating of coal. The measure for controlling the spontaneous heating of coal is making stopping in the mines, preventing the entry of oxygen from entering the particular area. This curbing of spontaneous heating ultimately controls the generation of the carbon monoxide in the air. Hirakhand Bundia Mines is a mechanized mine. In this mine trackless mining is done. The machines such as L.H.D, which is used for the production of coal in the mines, are electrically powered. Therefore the emission of gases such as CO, CO_2 is reduces
3. Nitrogen Oxide: **-** Proper blasting techniques are used in the mines. The explosive used in the mines has a special property as it can emit less nitrous fumes compared to other mines.
4. Particulate matter: **-** The ambient air quality of this mine is being monitored regularly. The air quality With respect to the SPM, RPM concentration levels at all the station levels located in the different points in the mines is found to be within limits. Various dust sprinklers is used in the area such as loading unloading and in transfer points. Various measures are taken to suppers dust such as sprinkling of water and proper cleaning of the haul road. So, different method that is employed in the mines for the suppression of the particulate emission are : -
    - ❖ Regular cleaning of spillages of material such as coal to prevent the dust being air borne.
    - ❖ Water spraying at transfer points.
    - ❖ Provision of proper ventilation in the underground mine to prevent accumulation of pollutants at work places.
    - ❖ Regular ventilation survey as per statutory requirement.
    - ❖ Careful removal of all loose coal from the abandoned coal face.
    - ❖ Adequate steps like water spraying arrangement at statutory distances and places.

- ❖ Prompt removal of wood cuttings, oil and grease from underground workings.
- ❖ Strict compliance of all preventive measures against underground mine.

Liquid waste management

The waste liquid which is generated during various operations from the mines is first of all taken to the underground sump where it is stored temporarily. Second stage the waste liquid from the underground is taken to the surface where it is stored in the settling tank. Alum and various chemicals are added to the water, the purpose of adding the alum is to settle the unwanted particles which is present in the water. Thirdly, water after settling, taken to another water tank where it is added with various chemical to purify the water. Water after purification is supplied to another tank where it is used for the various purposes.

Figure 3.3.3 Settling Tank on the Surface [16]

Control measures that are taken for mine discharge water

- ➢ Treatment of effluent quality (mine discharge water) before discharge to surface water course.
- ➢ Recycling of treated mine discharge water to achieve "zero discharge" to the extent possible.
- ➢ Provision of oil & grease trap, provision of drains around coal dump / stock yard.

On surface water sources

There is no significant or conspicuous drainage traversing the area except first order or over land flow slope. The subsidence on the surface of the core zone area after depillaring of the mine may create feature like micro-basin locally. The major impacts are water pollution due to oil & grease, contamination of water bodies due to discharge of mine water/effluents, pollution from domestic & sewage effluents.

Control measures

- Domestic waste water is treated in soak pit and septic tank combination provided to each unit.
- Recycling of treated mine discharge water to achieve "zero discharge" to the extent possible.

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3.4 WASTE MANAGEMENT IN ROURKELA STEEL PLANT

3.4.1 Introduction

Rourkela Steel plant is situated in Rourkela, District Sundargarh of Orissa State at an elevation of about 219 meters above mean sea level. The area of Rourkela is 200 square kilometers approximately. Red and laterite soils are found here which are quite rich in minerals. The area near Rourkela is rich in iron-ore hence a steel plant is situated in Rourkela.

Location

Rourkela Steel Plant is located in the Rourkela, District Sundargarh (Orissa). Geographically the area falls under following co-ordinates:

- Latitude: 22.12^{o} N
- Longitude: 84.54^{o} E

Steel Plant Description

Rourkela Steel plant is one of the integrate steel plant of SAIL

Table 3.4.1 Production performance of R.S.P [24], [27]

Products	Expected production (in MT)	2008-09 Apr to Nov (in MT)	2009-10 (In million tonnes)
Hot metal	2.00	1.5	2.27
Crude steel	1.90	1.42	2.13
Total saleable steel	1.67	1.98(Annual value)	1.989

Salient Features of Steel Plant

- It is the first plant in Asia to adopt LD process of steel making.
- It is the only plant producing large diameter ERW/SW pipes.
- It is the first steel plant in India to adopt external desulphurization of hot metal by calcium carbide injection process.

❖ It is the only steel plant in SAIL producing Cold Rolled non-oriented (CRNO) steel sheets for use in the electrical industries.

❖ It is the first integrated steel plant of SAIL which adopted the cost effective and quality centered continuous casting route to process 100% of steel produced

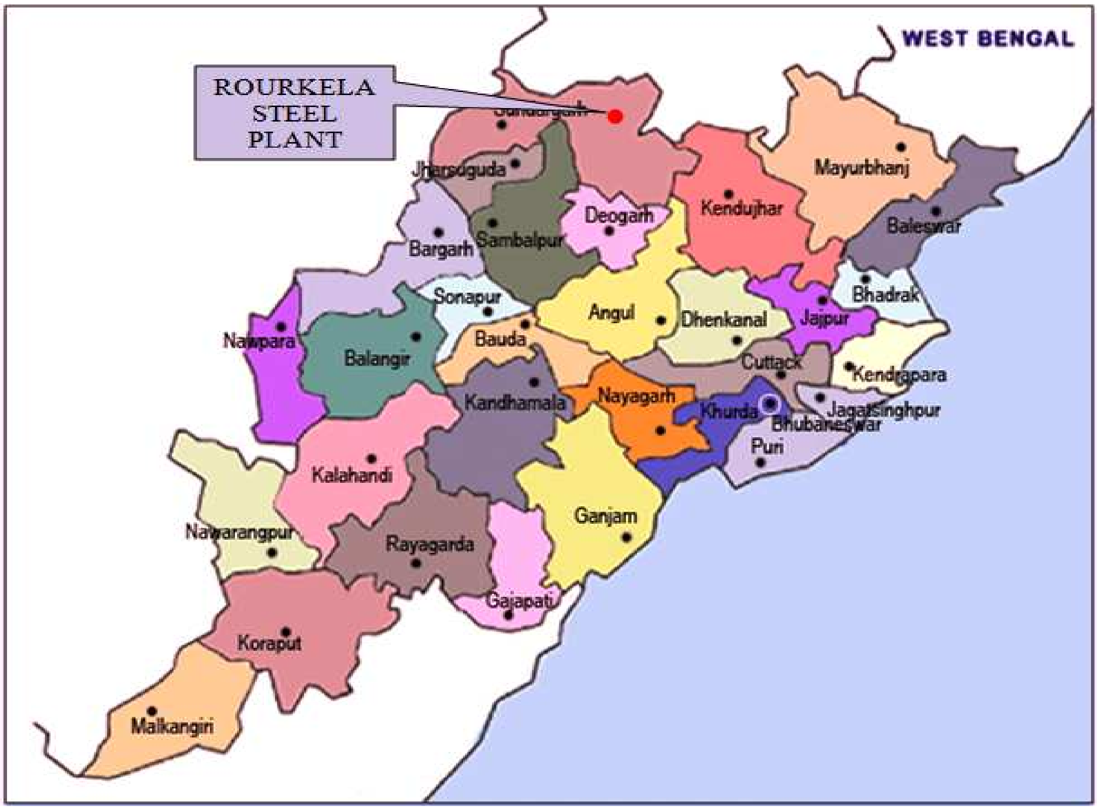

Figure 3.4.1 Location of Rourkela Steel Plant

Figure 3.4.2 View of Rourkela Steel Plant

3.4.2 STEEL PRODUCTION FROM IRON ORE IN RSP

Steel production at Rourkela steel plant involves three basic steps.

1. The heat source used to melt iron ore is produced i.e. coke making.
2. Next the iron ore is melted in a furnace.
3. Finally, the molten iron is processed to produce steel

Coke making

Coke is a solid carbon fuel and carbon source used to melt and reduce iron ore. Coke production begins with pulverized, bituminous coal. The coal is fed into a coke oven which is sealed and heated to very high temperatures for 14 to 36 hours. Coke is produced in batch processes, with multiple coke ovens operating simultaneously.

Heat is frequently transferred from one oven to another to reduce energy requirements. After the coke is finished, it is moved to a quenching tower where it is cooled with water spray. Once cooled, the coke is moved directly to an iron melting furnace or into storage for future use.

Figure 3.4.3 Coke Oven Battery [19]

Coke oven / by-product plant interface

In a by-product coke oven the evolved coke oven gas leaves the coke oven chambers at high temperatures approaching 2000F. This hot gas is immediately quenched by direct contact with a spray of aqueous liquor (flushing liquor). The resulting cooled gas is water saturated and has a temperature of 176F. This gas is collected in the coke oven battery gas collecting main. From the gas collecting main the raw coke oven gas flows into the suction main. The amount of flushing liquor sprayed into the hot gas leaving the oven chambers is far more than is required for cooling, and the remaining unevaporated flushing liquor provides a liquid stream in the gas collecting main that serves to flush away condensed tar and other compounds. The raw coke oven gas and the flushing liquor are separated using a drain pot (the down comer) in the suction main. The flushing liquor and the raw coke oven gas then flow separately to the by-product plant for treatment.

Composition of coke oven gas

Raw coke oven gas coming from the coke oven battery has the following typical composition:

Table 3.4.2 Raw Coke Oven Gas composition [18]

Generated product	**Dry basis**	**Actual composition (water saturated at 176°F)**
Water vapor	-	47%
Hydrogen	55%	29%
Methane	25%	13%
Nitrogen	10%	5%
Carbon Monoxide	6%	3%
Carbon Dioxide	3%	2%
Hydrocarbons (ethane, propane etc.)	2%	1%

Raw coke oven gas also contains various contaminants, which give coke oven gas its unique characteristics. These consist of:

- Tar vapors
- Light oil vapors (aromatics), consisting mainly of benzene, toluene and xylene (BTX)
- Naphthalene vapor
- Ammonia gas
- Hydrogen sulfide gas
- Hydrogen cyanide gas

Duties of the by-product plant

In order to make raw coke oven gas suitable for use as a fuel gas at the coke oven battery and elsewhere in the steelmaking facility the by-product plant must:

- Cool the coke oven gas to condense out water vapor and contaminants
- Remove tar aerosols to prevent gas line/equipment fouling
- Remove ammonia to prevent gas line corrosion
- Remove naphthalene to prevent gas line fouling by condensation

Other duties may include:

- Remove light oil for recovery and sale of benzene, toluene and xylene
- Remove hydrogen sulfide to meet local emissions regulations governing the combustion of coke oven gas.

In addition to treating the coke oven gas, the by-product plant must also condition the flushing liquor that is returned to the coke oven battery, and treat the waste water that is generated by the coke making process. By direct contact with re-circulated water spray, with the contact cooling water being itself cooled externally in heat exchangers. In the tubular type, the coke oven gas is cooled indirectly by flowing across horizontally mounted tubes through which cooling water is pumped. In this case, the cooling water does not come into contact with the coke oven gas and so it can be cooled in a cooling tower for example. As the coke oven gas is cooled, water, tar and naphthalene condense out. The condensate collects in the primary cooler system and is discharged to the tar & liquor plant.

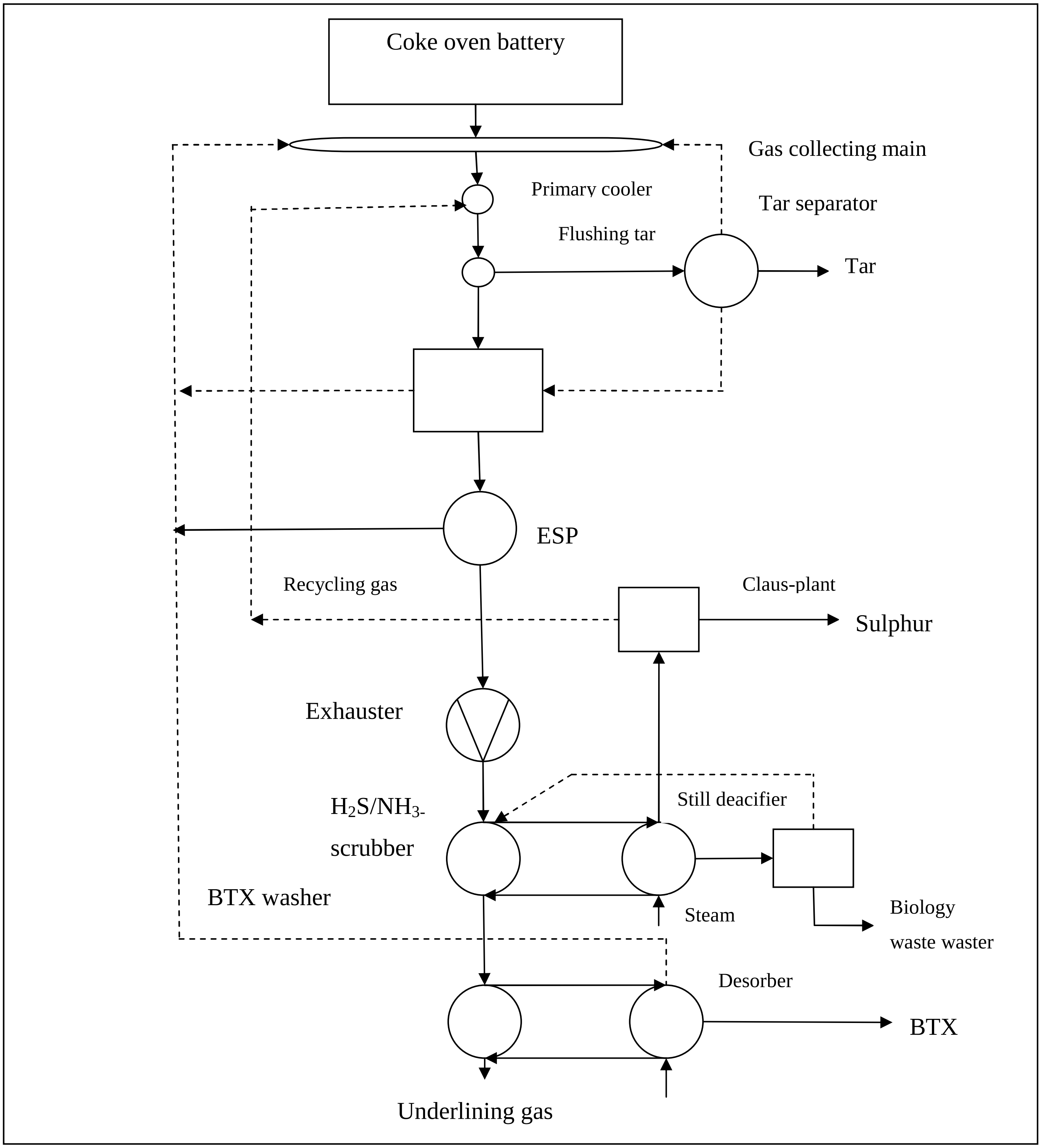

Figure 3.4.4 Flow Diagram of Coke Oven [18]

Table 3.4.3 Production Of By- Products from Coke Oven [18]

Stream	Destination	Typical quantities, based on 1 million tons per year coke
Coke Oven Gas	Used as fuel gas at the coke oven battery and steel works	50 million cu. ft./day
Flushing Liquor	Re-circulated back to the coke oven battery	Varies with plant design
Waste Water	Discharged to treatment plant	Varies with plant design
Tar	Sold as product	29,000 gallons/day
Ammonia/ Ammonium Sulfate	Sold as product	12 tons/day (as ammonia)
Light Oil (i recovered)	Sold as product	12,500 gallons/day
Sulfur/Sulfuric Acid (if gas is desulfurized)	Sold as product	Varies with coal properties and local requirements

Iron making

In an integrated iron and steel mill, iron is made directly from iron ore. Ores are agglomerated into pellets, nodules, sinter, or briquettes for further processing. The main component of iron making worldwide is the blast furnace. Agglomerated ore is charged with coke and crushed limestone that provides both the intense heat and chemical reduction necessary to produce molten iron.

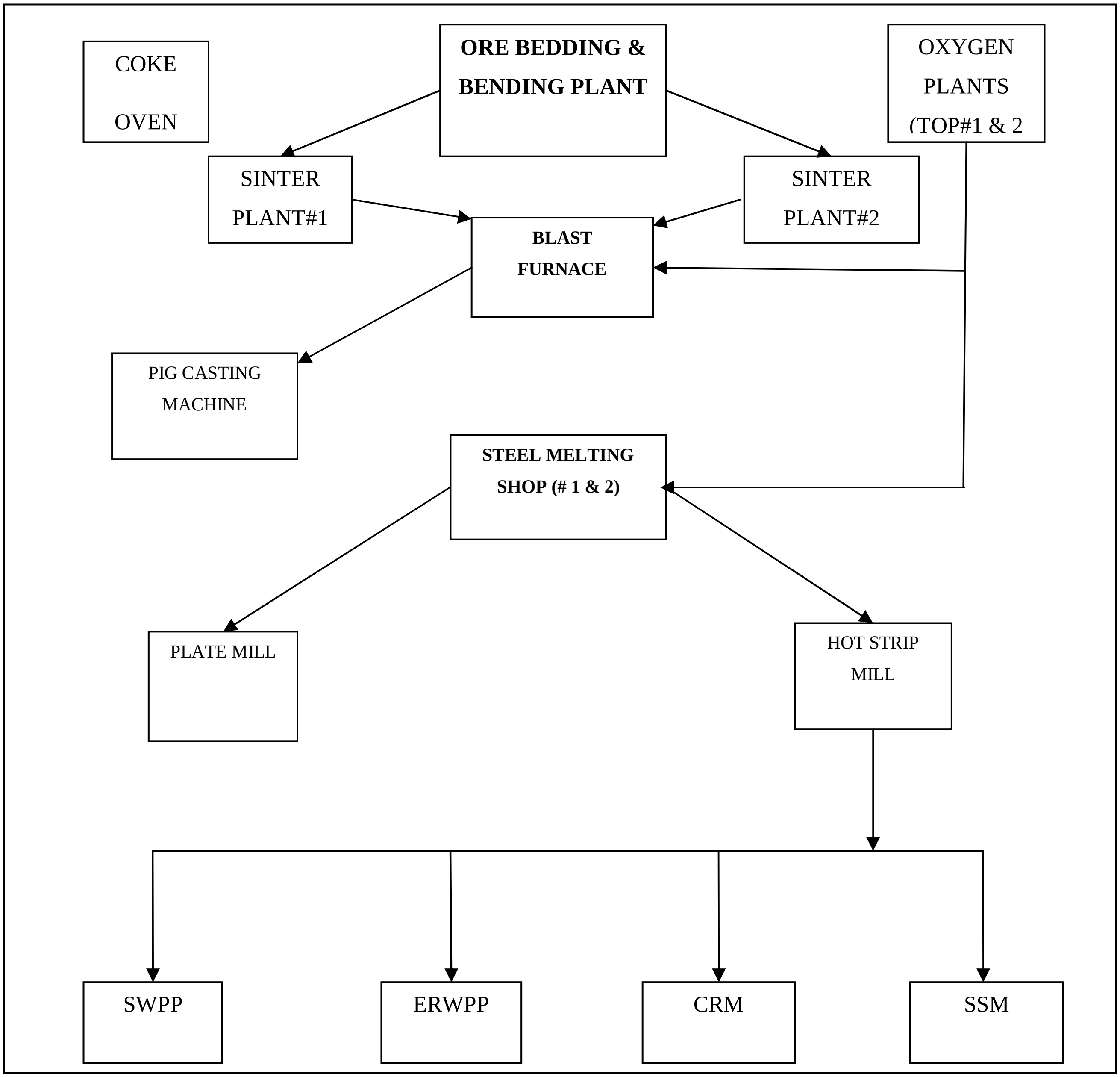

Figure 3.4.5 General Flow Diagram of Iron & Steel Making (Das, 2003)

3.4.3 WASTE GENERATION IN R.S.P.

Types of Waste Generated in RSP

The operations in an integrated steel plant are very complex. Several other activities such as power generation and production of refractories are also performed in varying degree inside the steel works. Vast quantities of raw material are handled and processed and different wastes are generated at every stage of operation. These wastes have wide ranging impact on the environment. These wastes generated pollute the environment. The different types of wastes which are encountered in the steel plant are as follows: -

1. Solid waste
2. Liquid waste
3. Gaseous waste

Generation of Solid Waste from RSP

To make one tone of crude of steel even with the good raw materials and efficient operation, 5 tonnes of air, 2.8 tons of raw material and 2.25 tones of water are required. These will produce in addition to one tones of crude steel, 8 tones of moist dust laden gases and 0.5 tones of solid wastes. However, in SAIL plants, this figure varies from 820 kg/tcs to 1045kg/tcs which are still very high. From the above it is clear that the main solid waste comprises [8]:

j) Blast furnace slag.
k) Steel making slag.
l) Sludge from sinter plant and blast furnace gas cleaning systems.
m) Dust recovered from de-dusting system.
n) Mill scale.
o) Fly ash
p) Waste refractories.
q) Raw material spilled out of the carrying system.
r) Waste consumables

Categories of Solid Waste

There are basically three categories of solid wastes. They are as follows:

4. Ferruginous solid wastes.
5. Non-ferruginous solid wastes.
6. Fly ash.

Ferruginous Solid Wastes: Solid waste which contain more amount of iron particles are considered as ferruginous solid wastes. These solid wastes are of more demand. They can be recycled and reused in various ways. These wastes contain more percentage of iron particles.

Example: Blast furnace flue dust, gas cleaning plant (GCP) sludge, LD sludge, sinter plant sludge, mill scale are some of the major ferruginous solid wastes.

Non-Ferruginous Solid Wastes: Solid wastes which do not contain iron particles are considered as non-ferruginous solid waste.

Example: acetylene sludge, refractory brick, limes fines etc.

Ferruginous Wastes

The iron bearing wastes, generated at different stages steel making are suitable for recycling back and reusing in place of raw materials after suitable processing. The recycling of ferruginous wastes back to process are not only replacing iron ore but also other raw materials like Iron ore (fines), Lime stone and coke breeze (coal).

Mill Scale: The mill scale which is nothing but oxides of iron, is generated when the hot slab, plates, coils are cleaned with water during rolling. Mill scale is generated from Steel Melting Shops, Hot Rolling Mills and Cold Rolling Mills. Mill scale is generated at a rate of 2% of steel rolled in rolling mills. The mill scale coming along with waste water is separated in waste water treatment plants. As mill scale is nothing but iron oxides, its recycling back to ore bedding and blending plant is replacing Iron ore (fines) to an extent of 115%. All the mill scales generated in Rourkela Steel Plant are recycled back and gainfully utilized.

Blast Furnace Flue Dust: The dust coming along with Blast furnace gas is first separated in dry form at Dust Catchers, is called Blast Furnace Flue Dust. The BFc Flue dust is generated at a rate of 50gms per one Tonnes of Hot Metal production. The chemical composition of BFc flue dust shows, these wastes can replace Iron Ore (fines) and Coke Breeze when it is recycled back or making base mix. Recycling of 1T of Blast Furnace flue dust is replacing 0.63T of fresh Iron ore (fines) and 0.37T of coke. All the Blast Furnace Flue Dusts are recycled back and gainfully utilized in Rourkela Steel Plant.

Furthermore, in some cases the dust contains toxic elements (Cd, Cr and As), which make it hazardous and unacceptable for landfill. Therefore, proper characterization followed by a suitable beneficiation method has to be evaluated in order to recycle within the plant [11].

Table 3.4.4 Physical and Chemical Properties of Typical BF Flue Dust Sample (Prakash, 2007)

Constituents	Mean (%)
Carbon	29.90
Fe_2O_3	51.10
SiO_2	6.31
Al_2O_3	5.12
CaO	4.90
MgO	0.88
Pb	0.024
Zn	0.042
MnO	0.58
K_2O	1.22
Na_2O	0.47
Fe(T)	35.7
Bulk density (g/cc)	1.42
Specific gravity	2.59
Porosity (%)	45.17

BFc sludge/SMS sludge: The micro fine particles separated from Blast Furnace Gas and BOF gas at Gas Cleaning Plant in the form of sludge is called BFc sludge/SMS sludge. The rate of generation of sludge is 0.018T of Tonnes of crude steel. The composition of sludges show, it can replace Iron Ore (fines) and Lime stone, when the sludges are recycled back for making sinter in Ore Bedding Blending Plant. One tones of Sludge replace 0.62T of Iron Ore (fines) and 0.38 T of lime stone, when it is recycled back for making base mix for sinter.

In order to meet the strict environmental requirements, it has become necessary for steel plants to develop a process of recycling this waste material. The sludge contains appreciable quantities of iron and lime and is therefore quite suitable for recycling in the sinter plant [11].

Table 3.4.5 Chemical Composition of the BOF Sludge Sample (Prakash, 2007)

Constituents	**Percent**
Fe (total)	64.12
FeO	79.58
Fe_2O_3	2.79
CaO	8.9
MgO	0.38
SiO_2	0.71
Al_2O_3	0.32
P	0.101
MnO	0.10

Handling and transportation of sludges are posing environmental problems. The spillages on roads during transportation, is the main problem with sludges recycling. Recycling throughout the year is not possible particularly during rainy season, as the sludges become wet and cause jamming in unloading facilities. In Rourkela Steel Plant, these sludges are utilized to an extent of 25%.

SMS Slag: Steel slag, a by-product of steel making, is produced during the separation of the molten steel from impurities in steel-making furnaces. The slag occurs as a molten liquid melt and is a complex solution of silicates and oxides that solidifies upon cooling.

Virtually all steel is now made in integrated steel plants using a version of the basic oxygen process or in specialty steel plants (mini-mills) are using an electric arc furnace process. The open hearth furnace process is no longer used.

There are many grades of steel that can be produced, and the properties of the steel slag can change significantly with each grade. Grades of steel can be classified as high, medium, and low, depending on the carbon content of the steel. High-grade steels have high carbon content. To reduce the amount of carbon in the steel, greater oxygen levels are required in the steel-making process. This also requires the addition of increased levels of lime and dolime (flux) for the removal of impurities from the steel and increased slag formation.

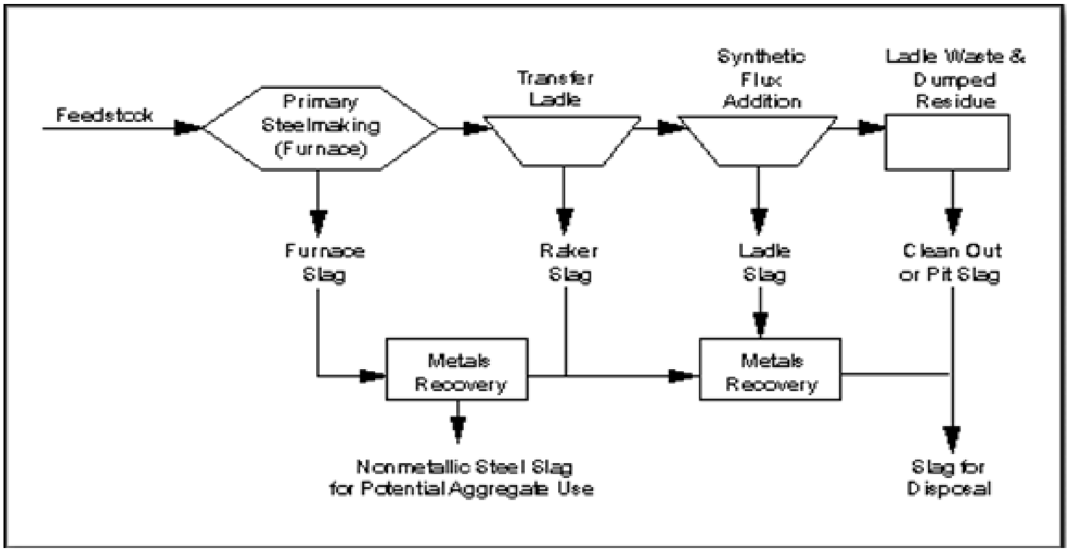

Figure 3.4.6 General Schematic diagram of SMS Slag Production [24]

Pit slag and clean out slag are other types of slag commonly found in steel-making operations. They usually consist of the steel slag that falls on the floor of the plant at various stages of operation, or slag that is removed from the ladle after tapping.

Table 3.4.6 Chemical Composition of Steel Slag (Prakash, 2007)

Constituent	**Composition (%)**
CaO	40-52
SiO_2	10 – 19
FeO	10 – 40 (70 – 80% FeO, 20 – 30% Fe_2O_3
MnO	5- 8
MgO	5 – 10
Al_2O_3	1 - 3
P_2O_5	0.5 – 1
S	< 0.1
Metallic Fe	0.5 - 10

All the railway tracks inside Rourkela Steel Plant (190 kms) are laid on SMS slag ballast. SMS slag is used for making all roads inside the Steel Plant and in Townships in Rourkela. Rourkela Steel Plant is gainfully utilizing SMS slags up-to an extent of 40-20% only. The high volumes of SMS slag generation is leading to its disposal on ground.

Blast Furnace Slag: In the production of iron, iron ore, iron scrap, and fluxes (limestone and/or dolomite) are charged into a blast furnace along with coke for fuel. The coke is combusted to produce carbon monoxide, which reduces the iron ore to a molten iron product. This molten iron product can be cast into iron products, but is most often used as a feedstock for steel production.

Blast furnace slag is a nonmetallic co-product produced in the process. It consists primarily of silicates, aluminosilicates, and calcium-alumina-silicates. The molten slag, which absorbs much of the sulfur from the charge, comprises about 20 percent by mass of iron production. Figure- 3 presents a general schematic, which depicts the blast furnace feedstock and the production of blast furnace co-products (iron and slag).

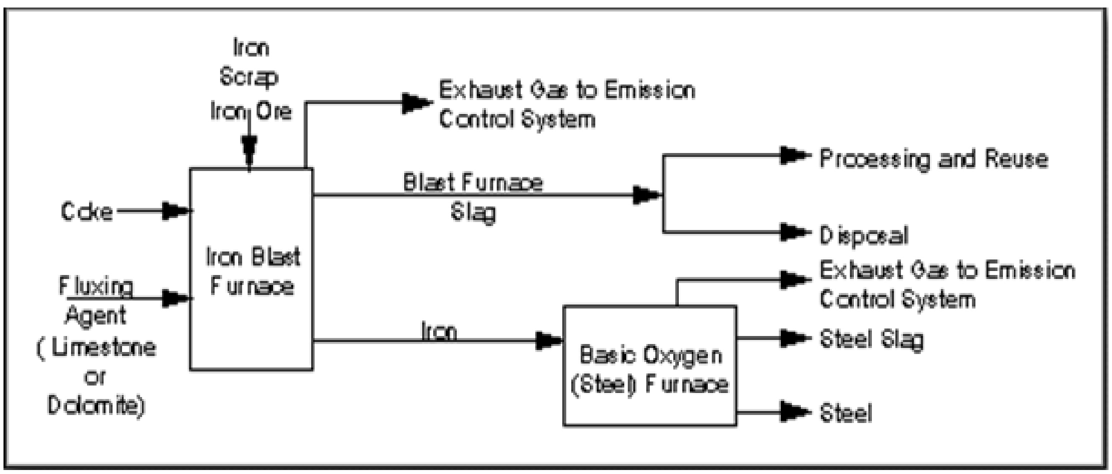

Figure 3.4.7 General Schematic diagram of Blast Furnace Slag Production [24]

Types of blast furnace slag

1. Air-Cooled Blast Furnace Slag

   If the liquid slag is poured into beds and slowly cooled under ambient conditions, a crystalline structure is formed, and a hard, lump slag is produced, which can subsequently be crushed and screened.

2. Expanded or Foamed Blast Furnace Slag

If the molten slag is cooled and solidified by adding controlled quantities of water, air, or steam, the process of cooling and solidification can be accelerated, increasing the cellular nature of the slag and producing a lightweight expanded or foamed product. Foamed slag is distinguishable from air-cooled blast furnace slag by its relatively high porosity and low bulk density.

3. Pelletized Blast Furnace Slag

   The molten slag is cooled and solidified with water and air quenched in a spinning drum, pellets, rather than a solid mass, can be produced. By controlling the process, the pellets can be made more crystalline, which is beneficial for aggregate use, or more vitrified (glassy), which is more desirable in cementitious applications. Rapid quenching of slag results in greater vitrification and less crystallization.

4. Granulated Blast Furnace Slag

   If the molten slag is cooled and solidified by rapid water quenching to a glassy state, little or no crystallization occurs. This process results in the formation of sand size (or frit-like) fragments, usually with some friable clinker like material. The physical structure and gradation of granulated slag depend on the chemical composition of the slag, its temperature at the time of water quenching, and the method of production. When crushed or milled to very fine cement-sized particles, ground granulated blast furnace slag (GGBFS) has cementitious properties, which make a suitable partial replacement for or additive to Portland cement.

Table 3.4.7 Constituents of Slag (Prakash, 2007)

Constituent	**Percentage**	
	Mean	Range
(CaO)	41	34-48
(SiO_2)	36	31-45
(Al_2O_3)	13	10-17
(MgO)	7	1-15
(FeO or Fe_2O_3)	0.5	0.1-1.0

(MnO)	0.8	0.1-1.4
(S)	1.5	0.9-2.3

Non Ferruginous Wastes

The non iron bearing materials used in steel industry for various purposes like refractory lining of converters, furnaces, making of acetylene, calcinations of lime and dolomite and boiler coal for captive power generation are generating various wastes, called Non Ferruginous Wastes They are,

- Used Refractory bricks
- Acetylene sludge
- Lime fines
- Dolomite fines
- Fly ash

Used Refractory Bricks: There is 60 thousand tonnes of refractory bricks used in the RSP per year. Out of which 1500T of used refractory bricks are salvaged for reuse and rest consisting mainly magnetite and chrome magnetite bricks are being sold. The rejected refractory bricks are used for pavement making in RSP.

Acetylene sludge: There are 2 acetylene plants for production of acetylene gas from calcium carbide. About 1700T of acetylene sludge is generated from these plants. This sludge is highly alkaline in nature and can be used for neutralization purposes. This sludge can also be used for white washing purpose. Presently the acetylene sludge is being sold out.

Dolomite and lime fines: During calcinations of dolomite and lime stone in calcining plant 2 and LDBP of Rourkela Steel plant, lot of dolomite and lime fines are generated from screening and captured in various dust extraction systems in the plant. The CaO content of these lime fines is ranging from 85-87% and gainfully utilized for neutralization purposes as well as white washing.

These lime fines are gainfully utilized as trimming addition in sinter plant 2. The lime fines are also being used for neutralization purposes in water treatment plants for township, neutralization units of Cold Rolling Mill.

Fly Ash: RSP is having two coal based captive power plant. The ash generated during the burning of coal called fly ash is disposed of by dry and wet methods. The fly ash generation is 36000T/month. Presently most of the fly ash is disposed off in wet condition in Ash ponds. The disposed fly ash is presently used for raising dyke height of ash ponds only. Arrangements were made MP Boiler-3 for disposal of fly ash in dry form and the response from cement manufacturers is very good for taking this fly ash in dry form. RSP is working on a project for installation of dry fly ash disposal facilities for other High Pressure Boilers also.

It is planned to sell Blast furnace sludge and SMS sludge to outside parties to increase utilization and get away from land pollution. Installation of in-house slag granulation at Blast Furnace 1 and strengthen the facilities at Slag granulation plant as per decided plan, will augment the Blast furnace slag granulation and increase the overall utilization of solid wastes in future.

Table 3.4.8 Types of Solid/Liquid Waste Generated From Steel Plants [17]

Solid/liquid wastes	**Hot metal (kg/t)**	**Source of generation**
Coke breeze	–	Coke oven
Nut coke	–	Coke oven
Coke dust/sludge	–	Coke oven
Blast furnace slag	340–421	Blast furnace
Blast furnace dust/sludge	28	Blast furnace
Sintering plant sludge	–	Sintering plant
LD slag	200	Steel melting shop
LD sludge	15–16	Steel melting shop
Lime fines	–	Steel melting shop
ACP/GCP sludge	–	Steel melting shop
Carbide sludge	–	Acetylene plant
Mill scale	22	Mills
Mill sludge	12	Rolling mills
Sludges/scales	–	Water treatment plant
Fly ash	–	Power plant

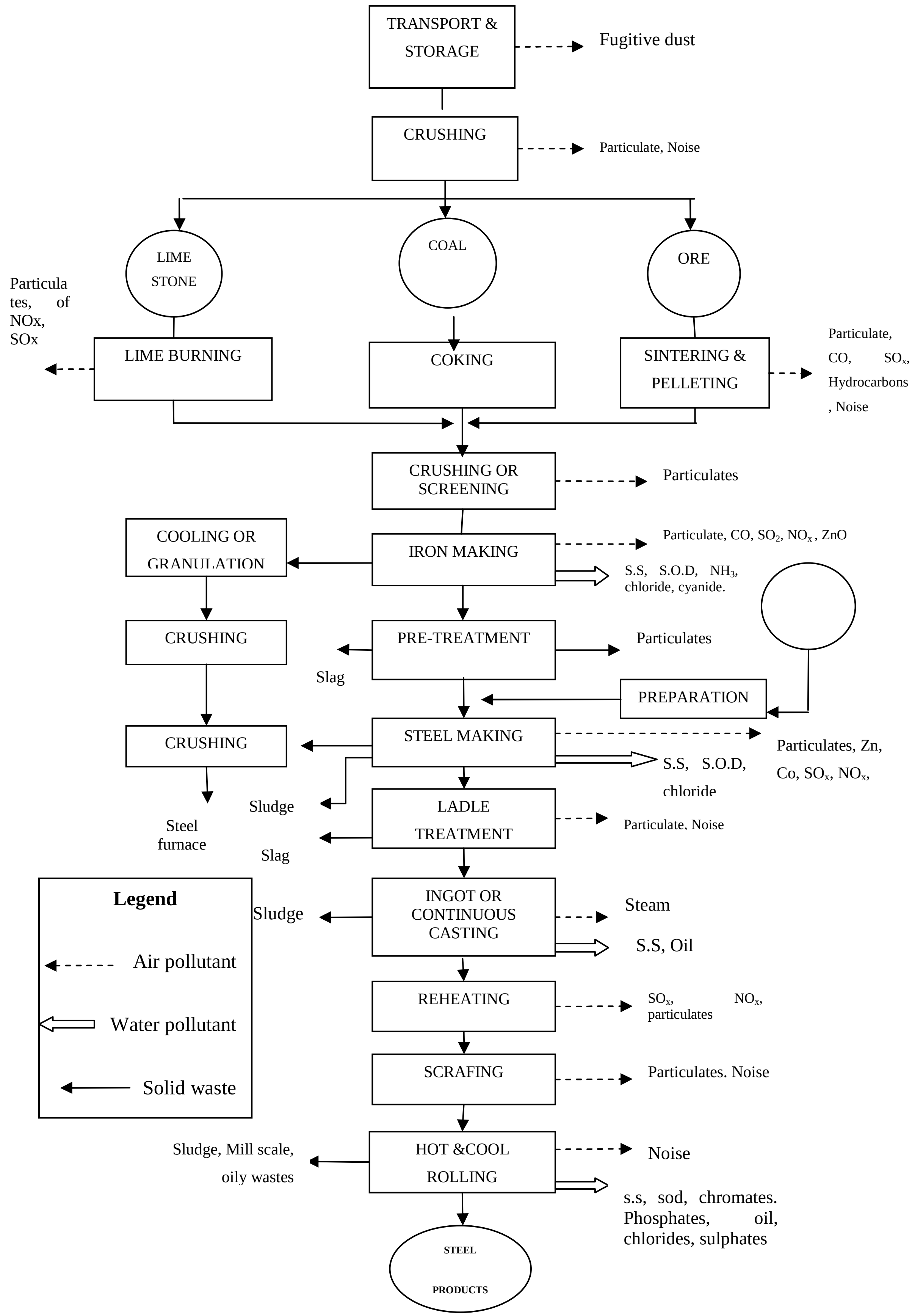

Figure 3.4.8.Flow Chart of Linking Pollutants & Principle Operation in an Integrated Steel Plant (Agarwal, 1999)

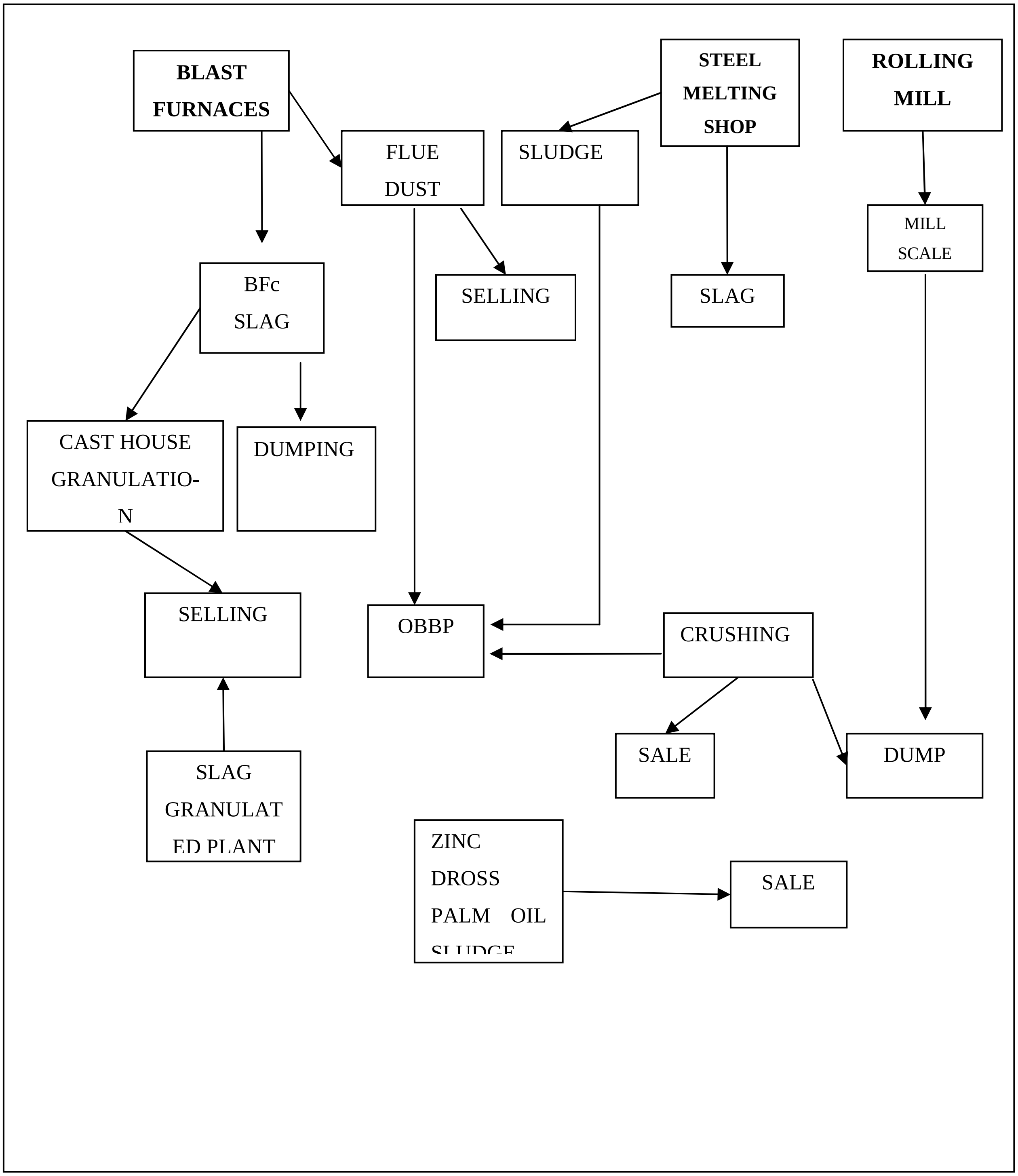

Figure 3.4.9 Solid Waste Generation in an Integrated Steel Plant (Das, 2003)

Generation of Liquid Waste from RSP

The Rourkela steel industry consumes much water. In order to produce one ton of steel it effectively pumps in from 100 to 200 m3, viz. 150 m3 on average, of which approximately 2 to 4 m3 have disappeared at the end of the cycle, either by evaporation, or consumption in the course of manufacture or incorporation in the wastes. For the manufacture of one million tons of ingot steel a year, this corresponds to:

- Pumped water 100—200 x 106 m3/year or 12500—25000 m3/h
- Waste water 2—4 x 106 m3/year or 250—500 m3/h

Per plant, the breakdown of the quantities pumped in is approximately as follows:

1. Sintering 0—20 m3/t sinter
2. Blast furnace 50—80 m3/t pig iron
3. Steel plant 2—20 m3/t steel
4. Rolling mills 2—80 m3/t rolled
5. Coke plant 2—5 m3/t coke
6. Blast furnace gas cleaning 3—7 m3/1 000 m3 gas.

Qualitatively

Water has many varied uses in the iron and steel industry—cooling (the most important use), power transfer, gas cleaning, matter removal—to mention only the main ones. The types of use are varied since one may find cooling circuits open, closed, with atmospheric coolant, with air convector and totally closed, with low pressure steam, with medium or high steam pressure, wasted or recovered, with natural or forced circulation. The water qualities vary according to the requirements of each circuit, and extend from raw water to treated water, from removal of carbon to a complete demineralization and conditioning.

Table 3.4.9 Water Pollution after Processing (Dohen, 1985)

Plant	Raw material used	Nature of finished product	Manufacturing process	Nature of waste introduced in water
Coke oven plant	Coal	Coke. Coke oven gas, byproduct	Coal heating in closed cells and at controlled rates	Phenols, cyanides, various tars, ammonia
Cast iron plant	Ore or Sinter	Pig iron for steel making	Iron ore reduction by carbon at high temp.	Cyanides, phenols, ammonia
Steel manufacture	Pig iron, scrap	Steel, slag	Combustion of impurities contained in pig iron	Suspended solids, lime
Hot rolling	Liquid steel or ingot	Blooms, billets slab	Continuous casting	Lime, suspended solids, oils
Cold rolling	sheets	Thin sheets	Cold rolling	Oils, suspended solids

Rourkela Steel Plant gets water from river Brahmani through Tarkera Pump House. The raw water pumped from the river is distributed through a ring main to different departments for use in the process and for cooling purposes. RSP has adopted a 2-tier system of wastewater treatment. The effluent generated from the process is first treated in the department itself in the effluent treatment plant so that the all statutory norms are met before discharging into drains. The captive drains carry the total treated wastewater from different departments to a final treatment system i.e., an oxidation pond, called as Lagoon. Lagoon is a shallow aerobic oxidation pond where the pollutants are oxidized by bacteria. The treatment in lagoon is basically due to equalization, sedimentation, and photochemical oxidation. The final effluent from lagoon is periodically monitored for different parameters to ensure meeting the statutory norms before discharging into to river Brahmani. The various pollutants generated from different process and the method of treatment adopted in RSP is given below:

Table 3.4.10 Generation of Water Pollution (Dohen, 1985)

Sl. No.	Pollutant	Source	Treatment System	Norm (CPCB) guideline
1.	Acidity/Alkalinity (Parameter is pH)	• CCD – Sulphuric acid plant • DM plants in CPP, CRM, and SMSs etc. • CRM – Pickling lines • SSM – Pickling line	• Catch pits along with BOD plant • Neutralization plant • Neutralization plant • Neutralization plant	6-8.5
2.	Suspended Solids	• BFc – Gas Cleaning Plants • SMS – Gas cleaning plants • Rolling Mills – Descaling operations	• Sedimentations tanks/Clarifloculators/Vacuum filters/Drum filters/Belt filter systems	100 mg/l
3.	Oil & Grease	• Rolling Mills return water • SSM return water • SMS#2 return water • T&RM – Loco shed • CCD	• Oil skimmers – Trough type, Endless rope type, Belt type oil skimmers & Dissolved air floatation system with oil skimmers in BOD plant of CCD	10 mg/l
4.	Phenol	• CCD – By product plant	• BOD plant – Activated Sludge Process	1.0 mg/l
5.	Cyanide	• CCD – By product plant	• BOD plant – Trickling filter	0.20 mg/l
6.	Ammonical – Nitrogen	• CCD – By product plant	• BOD plant – Activated sludge process	50 mg/l

7.	Organic matter - BOD & COD	• All departments	• Lagoon - a shallow aerobic oxidation pond	BOD – 30 mg/l COD – 250 mg/l

Generation of Gaseous Waste form RSP

The different processes which add to the gaseous wastes in the steel industry are as follows:-

1. Coke production
2. Sinter production
3. Iron making
4. Steel making
5. Finishing
6. Alloying
7. Casting and shaping

Coke production

Coke is coal from which the volatile components have been removed by heating to high temperatures in the absence of oxygen. Nearly all coke produced in the integrated iron and steel industry is manufactured using the "byproduct" coke process. Byproduct coke ovens may release volatile organic compounds (e.g. benzene, butane, butylene, ethane, ethylene, hydrogen cyanide, methane, propane, propylene, toluene, and xylene) through leaks in any part of the system, including the coke oven lids and doors; through the standpipes and within the plant, itself; and while the coke is being removed, or "pushed," from the oven.

Sinter production

Sinter is an agglomerate of materials recovered from the iron and steel making process that is recycled into the iron making process at the blast furnace. Many sinter plants have shut down in recent years, in part because of difficulties associated with keeping the sinter operations in compliance with ‘environmental regulations. A wide variety of organic and heavy metal HAPs may be released at the sinter operation; organic HAPs can be released from coal and coke on the sinter grate and from organic solvents frequently found on scrap metals. Heavy metal HAPs may be released (as particulate) from the iron ore. Total HAPs releases from individual sinter manufacturing operations may exceed 10 tons per year.

Iron making

In steel industry practice, coke, iron ore and other materials are heated in a blast furnace to produce molten iron. Most of the HAPs (Hazardous Air Pollution) generated in the blast furnace are heavy metals, including cadmium, chromium, lead, manganese, and nickel. Emissions from the blast furnace are controlled by a wet venturi scrubber or another control device and may total several tons per year per blast furnace. Pollution prevention opportunities for the reduction of heavy metals at the blast furnace are somewhat limited, because heavy metals are an inherent part of the iron ore material stream and because iron production is directly proportional to the amount of ore used.

Steelmaking

In typical practice at integrated iron and steel operations, steel is made by blowing oxygen into a blend of molten iron and scrap steel in a basic oxygen process furnace (BOF). As in the case for the blast furnace, most of the HAPs generated in the BOF are heavy metals, including cadmium, chromium, lead, manganese, and nickel. Emissions from the BOF are controlled by an electrostatic precipitator or venturi scrubber and may exceed 10 tons per year per BOF. Pollution prevention opportunities for the reduction of heavy metals at the BOF are also somewhat limited, because heavy metals are an inherent part of the iron ore material stream and because iron production is directly proportional to the amount of ore used. Factors affecting HAPs emissions from the BOF include the degree of oxidation of the molten steel and the amount of time required to process the melt. Iron oxide emissions increase with the amount of time the hot metal is exposed to air and agitated by the heating process or during transfer.

Alloying

After steel is removed from the BOF, additional purification and alloying steps can be conducted at a metallurgical station. HAPs emissions from these processes are considered to be relatively low; few HAPs P opportunities have been identified. Refinements in the alloying process, particularly the process of ladle-metallurgy, do provide the P benefit of reducing energy requirements and reducing wasted steel by virtue of increased accuracy and speed in creating the desired steel composition.

Casting and Shaping

Two principal methods are used to form molten steel into solid form are: -

1. ingot casting and
2. Continuous casting.

In ingot casting: - molten steel is poured into molds where it cools into an ingot which is later machined into final form.

Continuous casting: - This method eliminates the ingot step, thereby reducing the degree of reheating and rolling necessary to manufacture semi-finished products.

More importantly, continuous casting greatly reduces the amount of energy required to create semi-finished steel. Continuous casting saves energy because much less scrap is generated in the manufacture of semi-finished steel. Yields from continuous casting are 15 to 20 percent greater than from ingot casting. The largest material savings comes from eliminating crop losses associated with the top and bottom ends of ingots cast in molds. Other benefits include shorter pouring times and transfer times from the BOF to the caster as compared to teeming steel to multiple molds. Also, continuous casting eliminates much of the reheating required to process ingots produced from molds. Most companies have converted from ingot casting to continuous casting, and more plan to do so in the near future. It is estimated that approximately 80 percent of the semi-finished slab steel in the world is manufactured via continuous casting. Not all steel can or should be manufactured by continuous casting, for reasons such as small batch sizes for specialty steels, or for the desired shape or size of the end product. For those operations that cast steel in molds, some operational changes such as bottom pouring instead of top pouring may reduce total emissions. Bottom pouring exposes much less of the molten steel to the atmosphere than top pouring, thereby reducing the formation of particulate or the air pollutants that are generating from the casting of the steel.

Finishing

Finishing steps include pickling and galvanizing to treat the surfaces of semi-finished metal products. Hydrochloric acid (HCl) bath pickling is the most common method used to remove iron oxide from the surface of semi-finished steel products; hydrofluoric acid (HF) is also used in some specialty steel applications. Hydrogen chloride is the primary hazardous air pollutant **(HAP)** associated with pickling, with emissions from surface pickling typically well over 10 tons per year per facility.

The integrated iron and steel industry encompasses all the steps included in the manufacture of steel from iron ore and other materials. Major processes in the production of finished steel include coke production, sinter production, ironmaking, steelmaking, alloying, casting and shaping, and finishing. The basic oxygen furnace, sinter plant, electric arc furnace, and hydrochloric pickling lines were considered to have the greatest potential to emit heavy air pollution (HAP).

Gaseous wastes are the wastes which are gaseous in nature. These wastes are produced during different operation in the steel making. These are gaseous and particulate emissions. The gaseous emissions are carbon oxides, nitrogen oxides and sulphur dioxide. They are also found in exhaust of electricity generation, emission from the stacks and through chimney emission (Marsosudiro, 1995).

Air pollutants are coming into environment from various operations in different departments. The air pollutants are further divided into Suspended particulate Matter (SPM) and Gaseous pollutants. The air pollutants, which are not gases, are called as SPM. Depending up on the size of the particle and their process of origin, these SPMs are further categorized as;

- Dust – Particle size up to 10 microns, formed mainly due to sedimentation and crushing.
- Fumes – Particle size less than 1 micron, formed mainly due to metallurgical operations.
- Smoke – Particle size less than 1 micron, formed mainly due to chemical operations.
- Fog – Particles size upto 10 microns, primarily containing water droplets.
- Mist – Particle size upto 10 microns, primarily containing chemical droplets.

The list of air pollutants, their source of generation, pollution control technology adopted by RSP is given below;

Table 3.4.11 Generation of Air Pollution (Marsosudiro, 1995)

Sl. No.	Pollutant	Source	Process	Pollution Control Equipment
1.	Suspended Particulate Matter (SPM) – Dust	Stack emissions from • Coke Ovens • Sinter Plants • Power Plant • Steel Melting Shops • Rolling Mills • Material Transfer Points (Conveyor belt transfer points)	• Flue gas firing • Sinter Making & gas firing • Fuel firing in boilers • Metallurgical operations • Flue gas firing in reheating furnaces • Crushing, sedimentation	• -- • ESPs • ESPs and Bag houses • ESPs and Bag Houses • -- • Bag houses
2.	Gaseous pollutants • SO_2 • NO_x	• Sulphuric Acid Plant • Nitric Acid Plant		• Scrubbers

Waste Generation from Various Units of R.S.P

A**. Blast Furnace**

1. **Blast furnace slag**
   Quantity generated: - 75000 t/month.
   Utilization: - On an average 80% is utilized
   Utility: - Sold to cement industry.

2. **Blast furnace flue dust**
   Quantity generated: - 1000 t/month
   Utility: - Recycled in steel manufacturing process

3. **Blast furnace sludge**
   Quantity generated: - 300 t/month
   Utility: - Partially recycled.

B. **Steel Melting Shop**

1. **S.M.S Sludge**
   C 3500 t/month
   Utility: - Recycled for steel making

2. **S.M.S Slag**
   Quantity generated: - 30,000 t/month
   Utility: - Recycled approximately 3.5%
   - It is sold.
   - Land rehabilitation purpose.
   - Proposed to be used in cement kiln.

C. **Lime Dust**

Source: - limestone calcining plant

Quantity: - 3000 t/month

Utility: - Recycled and Sold

Used in water treatment plant and in White washing.

D. Acetylene Sludge

Source: - Acetylene plant.

Quantity: - 200t/month.

Utilization: - Sold.

E. Mill Scale

Quantity: - 3000 t/month.

Utilization: - 100% recycled.

F. Used Fire Clay Bricks

Quantity: - 150 t/month.

Utility: - 100% recycled.

G. Fly Ash

Source: - Power plant.

Quantity: - 1500 t/day.

Utility: - Low lying area filling sold to brick manufacturer and is used for embankment.

H. Department Coal Chemical Plant

Table 3.4.12 Generation of products from Coal Chemical Department [17]

Generated product	Quantity Generated
Tar sludge	50 tons/year.
Acid tar	3 tons/year.
Sulphur Muck;	250 tons/year.
V_2O_5 catalyst;	2 tons/year.
BOD plant sludge;	8 tons/year.
Catch pit sludge;	50 ton/year

I. Department Of Cold Rolling Mill

Table 3.4.13 Generation of products from Cold Rolling Mill [17]

Generated product	Quantity Generated
Oily sludge;	0.2 t/ year
Zinc Dross;	1000 t/ year
Tin ash;	0.1 t/ year
Dichromate sludge	0.5 t/ year
Pickling sludge;	40 t/ year

J. Department Of Silicon Steel Mill

Table 3.4.14 Generation of products from Silicon Steel Mill [17]

Generated product	Quantity Generated
Pickling bath sludge;	15 t/year
E.T.P sludge;	40 t/year
Waste oil;	80 t/year

K. Department Of Traffic and Raw Material

Table 3.4.15 Generation of products from Traffic and Raw Material [17]

Generated product	Quantity Generated
Used oil;	12 t/year
Oily sludge	5 t/year
Contaminated filter waste;	5 t/year

L. **Foundry Department**

Table 3.4.16 Generation of products from Foundry Department [17]

Generated product	Quantity Generated
Non ferrous waste;	0.5 t/year
Rejected sand;	15 t/ year
Back filter dust;	2 t/ year

M. **Department Of Special Plate Plant**

Table 3.4.17 Generation of products from Special Plate Plant [17]

Generated product	Quantity Generated
Sand blasting filter dust	1 t/year
Grinding waste;	0.5 t/year
Oil quenching sludge;	1 t/year

N. **Electrical Repairing Shop Department**

- Cleaning solvent sludge; Quantity generated: - 0.5 t/year

O. **Department of Hot Strip Mill**

Table 3.4.18 Generation of products from Hot Strip Mill [17]

Generated product	Quantity Generated
Rejected sand from filter unit;	60 t/year
Oily sludge;	10 t/year

P. **Department E.R.W & S.W. Pipe Plant**

- Oily sludge; Quantity generated: - 2 t/year

(H – P) Department are generating hazardous waste, partially the waste are sold mainly Zinc dross, used oil, tin ash and partially recycled inside the pant for heat recovery. Again there is plant to neutralize the hazardous waste and ultimately will be managed through secured land filling.

Wastes are categorized into two types on the basis of their hazardous characteristics, which are as follows:

1) Hazardous waste
2) Non- Hazardous waste

Hazardous waste inventory are done based on schedule (1) and schedule (2) of hazardous waste management & handling rule 2008.

The hazardous wastes are sold to the authorized recycler, those who have got the authority from Ministry-of-Environment and forest.

Table 3.4.19 Data of Solid Wastes Generation from Steel Making in RSP (Das, 2003)

Sl. No.	SOLID WASTE	SOURCES OF GENERATION	QUANTITY OF GENERATION IN (TONNES)	QUALITY	UTILIZATION (%) 2008-09
1.	BFc slag	Blast furnace	881897	Fe=46-52%; CaO=22-30 MgO=4-10%; MnO=2-6% SiO_2=26-31%	82.47%
2.	SMS slag	Steel melting shop	345534.9	FeO=18-21%; SiO_2=16-18% CaO=47-53%	45.05%
3.	Blast furnace flue dust	Blast furnace dust catcher	15960	C=2.13%,; LOI=19.4-43.6% Fe=30-40.5%; SiO_2=7.4-11.6% CaO=2.3-4.6%;MgO=0.5-1.2	100%
4.	SMS sludge	Waste water treatment plant of SMS	366917	C=2.13%,Fe=51.8%; MgO=2.0 S=0.21%; SiO_2=2.1; CaO=12.8 LOI=6.7%	20.29%
5.	Mill scale	Rolling Mill waste water treatment plants	34960	Mixture of iron oxides	97.71%
6.	Acetylene sludge	Acetylene plant	2502	SiO_2=4-6%; Al_2O_3=1-3% CaO=60-70%	100%
7.	Calcined lime Fine	Calcinations Plant#2 & LDBP	33181	CaO=70-80%; MgO=3.5% SiO_2=1.7%; Al_2O_3=3.5%	100%
8.	Used refractory bricks	From relining of convertors, furnace and ovens	4359	Basically CaO, Al_2O_3 and traces of Fe_2O_3 and MgO	100%

Discussion

The solid waste generated from the Rourkela steel plant in given the Table 3.4.19. Some of the solid waste generated from the steel plant such as blast furnace flue dust, acetylene sludge, calcined lime Fine, Used refractory bricks are 100% utilized within the steel plant. Some of the solid waste such as blast furnace slag, SMS slag and SMS sludge are not fully utilized, among which SMS slag and sludge utilization is below 50%.

3.4.4 DISPOSAL OF WASTE IN RSP

Steel plant on the process of manufacturing steel emits and produces several harmful gases, liquid and solid wastes. Waste produced may be hazardous and non – hazardous in nature depending upon the characterization and properties of the waste. Further, different waste generated is disposed in the environment. Disposal of the waste is done in a very scientific way, in the steel industry such that these discharges do not contaminate and damages inland waters, environment, air quality, country side, food, human settlement and even flora and fauna. These wastes are classified into three different basic categories:-

a) Wastes which are not hazardous and recovery and recycle and reuse of valuables in it could be done successfully.
b) Wastes which are hazardous in nature and must be treated suitably.
c) Wastes which are not hazardous but recovery recycle and reuse may not be economical.

Waste disposal of Non-Hazardous Waste

Solid waste disposal

Disposal of blast furnace slag: It is estimated that a relatively small percentage (less than 10 percent) of the blast furnace slag generated is disposed of in landfills, dump yard and may be further reused as per the condition.

Disposal of steel slag: While most of the furnace slag is recycled for use as an aggregate, excess steel slag from other operations (raker, ladle, clean out, or pit slag) is Pollution Sources and Prevention in the BOF Slag is a major component of the waste produced in BOFs. Because of its composition, this slag, unlike that from the blast furnace, is best used as an additive in the sintering process. As its metallic content is lower, it does not make a good raw material for the construction industry these usually are sent to landfills for disposal as well as in the dump yard.

Various dumping yard here are as follows:

- Sitalpara dump yard.
- Ash pond A.
- Ash pond B.
- Ash pond C.

Dump yard of Rourkela steel plant

Fly ash

There are presently there are three fly ash ponds for the disposal of the fly ash, these are as follows:-

1. Pond A.
2. Pond B.
3. Pond C.

Table 3.4.20 Details of Fly Ash Pond [17]

Sl. No	Pond	Capacity in Acers	Life (in Years)
1	A	47	1 - 2
2	B	35	2
3	C	36.5	1- 2

Table 3.4.21 Distance of Fly Ash Pond from Power plant [17]

Sl. No	Pond	Distance from CPP1 (in km)	Distance from CPP2 (in km)
1	A	4	1
2	B	4.5	1.5
3	C	4.8	1.8

On an average 1500 ton/ month of fly ash is being generated by both the power plant (CPP1, CPP2). The dry fly ash collected in the ESP is disposed to ash pond in the slurry form by adding water in the dry ash. The filled up ponds are excavated and filled in the low-lying area. After filling the pond, the top surface is covered with sweet soil or slag to protect it from becoming air-borne. Presently few brick manufacturer are being explored who are regularly lifting the dry fly ash from the ESP for brick manufacturing, to enhance the ash utilization. RSP has taken a strategic decision to use only the fly ash bricks in the o going modernization of the plant

The transportation of the fly ash from the power plant to the ash pond is through pipes in slurry form. Generally the maximum height of the pond has gone up from RL – 211 to 235m. These levels are obtained gradually by raising the embankment height of the pond.

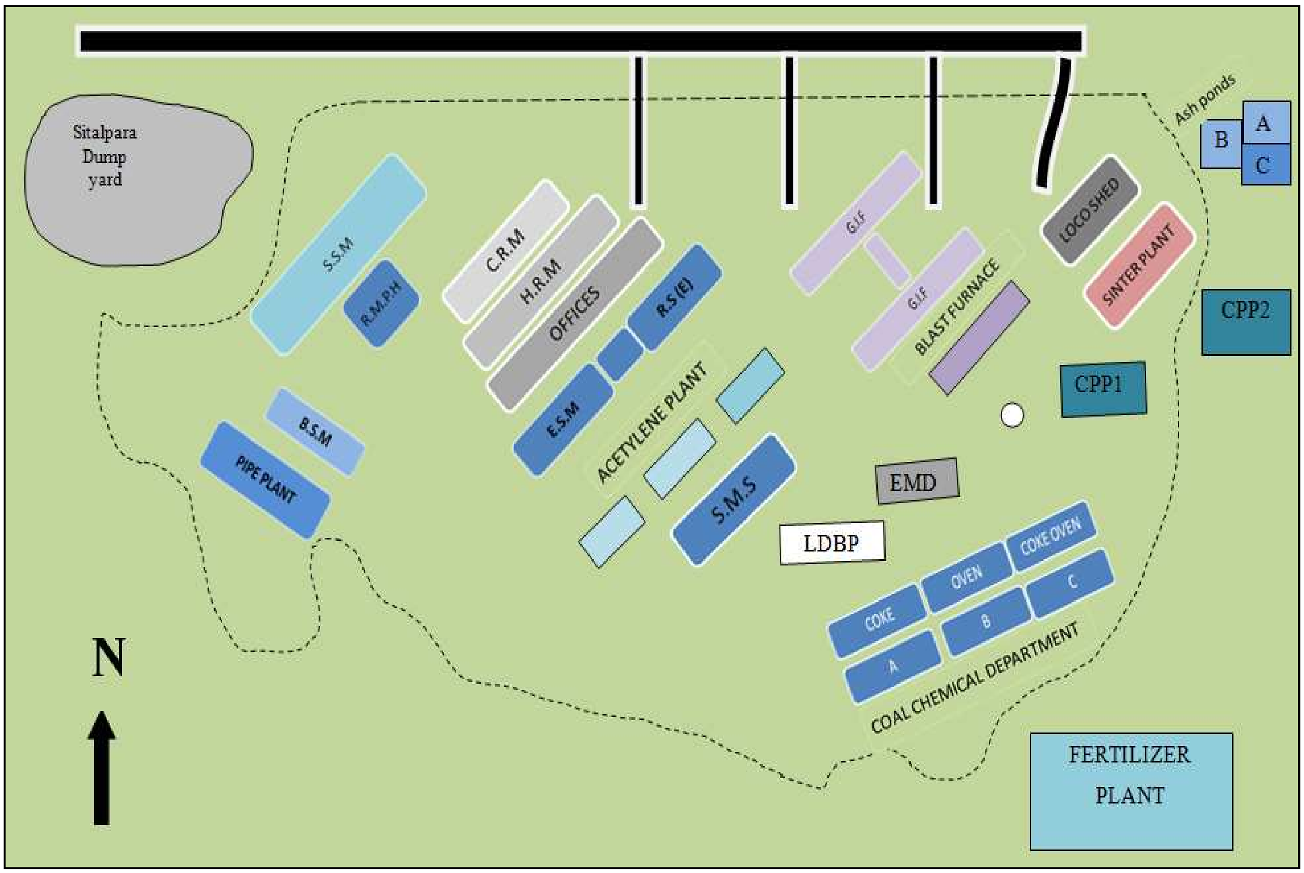

Figure 3.4.10 Layout of the Rourkela Steel Plant [17]

SMS Slag (Sitalpara dump yard)

SMS Slag is dumped outside the factory premises, at the western side of the plant. However the materials are processed by an outside public sector agency to use the material for plant use as well as to sole outside parties. Presently the utilization of slag is around 40 – 45% of the generation. As per the narrative by the Ministry of Environment and Forest the utilization is in phases.

Table 3.4.22 Details of SMS Dump Yard [17]

Sl. No	SMS dump yard	Area (in Acer)	Dis. from SMS shop (in km)
1	Sitalpara dump yard	80	2 – 3

Figure 3.4.11 Sitalpara Dump 1 of R.S.P

Figure 3.4.12 Sitalpara Dump 2 of R.S.P

Therefore, these wastes are disposed or kept even before recycling, with taking adequate care. The different wastes which are disposed or discharged in the environment using different method and techniques are: -

Disposal of Gaseous waste

Various states of art and technologies are adopted in both the Coke Oven and Blast Furnace or BOF Furnace. Further, to keep environment clean, many technologies had also been incorporated.

Hot gases are also produced by the BOF. Furnaces are equipped with air pollution control equipment that contains and cools the gas. The gas is quenched and cooled using water and cleaned of suspended solids and metals. This process produces air pollution control dust and waste.

Proper measures are being adopted with regard to control of emission during the whole process of steel making to reduce fugitive emission. Air pollutant, which is produced are emitted to the atmosphere after arresting maximum hazardous substance. The discharge of the pollutant i.e. air pollutant is done through chimney which are built in accordance with the norm.

Disposal Liquid Waste Disposal and Effluent Management

Waste water from the steel making process is being treated with best available physio-chemical methods as well as being recycled. Waste water from the coke plant is treated biologically where organic pollutants are oxidized and decomposed by micro organisms. Proper measures are taken at different units. The wastes after usage is further treated and are released from the steel plant to natural water bodies, nearby to the plant. The liquid waste or waste water is discharged through proper channels with the help of different outfalls.

Waste disposal of Hazardous Waste

The wastes which are falling under Schedule #1 and Schedule #2 of Hazardous Waste (Handling and Management) Rules, 1989 amended in May, 2003 are termed as Hazardous Wastes. These wastes can only be disposed in scientifically designed hazardous pits as per the guidelines of Central Pollution Control Board. The steel plant has to obtain prior authorization for handling and management of these wastes under Hazardous Waste Rule, 1989. Rourkela Steel Plant constructed 3 no. of scientifically designed hazardous waste pits at SSM complex, near CCD area and SSD area. The list of the wastes management by RSP is given in Table

Table 3.4.23 Data for Generation Hazardous Waste [17]

Sl. No	UNIT	WASTE DESCRIPTION	SCHE-DULE	WASTE STREAM/ CLASS	QTY. T/YEAR	HAZARDOUS WASTE MANAGEMENT
1.	COAL CHE-MICALS DEPT. (CCD)	CATCH PIT SLUDGE	1	SN 13	35	Disposed in hazardous waste pit at CCD
2.		V2O5 CATALYST	1	SN 17	0.8	-do-
3.		WATER TREATMENT SLUDGE	2	-	4	-do-
4.		DECANTER TAR SLUDGE	1	SN 13	350	Sold to outside parties who are having authorization with SPCB/ MoEF/ CPCB earlier. It has been decided to recycle this waste back to Coke Ovens.
5.		DRAIN SLUDGE	2		40	Disposed in hazardous waste pit at CCD
6.		SULPHUR MUCK	2	D1	400	-do-
7.	BLAST FURNACE	DRAIN SLUDGE	2		40	-do-
8.	ROLLING MILLS	PALM OIL SLUDGE	1	SN 13	300	• Sold to parties who are having authorization from SPCB/CPCB/MoEF. • Presently Palm oil system is replaced with semi synthetic oil system in CRM. There is no generation of palm oil sludge at present.
9.		ZINC DROSS	2	C14	1400	Sold to parties who are having authorization with

						SPCB/MoEF/CPCB
10.		OILY SLUDGE FROM OIL STORAGE TANK	1	SN 5	0	Tanks are cleaned only once in 7 years. No sludge arising during 2004-05.
11.		USED OIL	1	SN 5	120	Sold to parties who are having authorization with SPCB/MoEF/CPCB
12.		TIN BATH SLUDGE	2	B7	5	Disposed in hazardous waste pit.
13.		SODIUM DICHROMATE SLUDGE	2	A5	10	-do-
14.		PICKLING BATH SLUDGE	1	SN 13	40	-do-
15.	SIICON STEEL MILL	PICKLING LINE SLUDGE	1	SN 13	10	Disposed in hazardous waste pit at SSM
16.		ACID TREATMENT PLANT OIL	1	SN 12	80	Sold to parties who are having authorization with SPCB/CPCB/MoEF
17.		CLARIFIER SLUDGE	1	SN 12	30	Disposed in hazardous waste pit inside SSM.
18.		DRAIN CLEANING SLUDGE	2		10	-do-
19.	SWPP	OILY SLUDGE	1	SN 13	2	Disposed in hazardous waste pit
20.	ERWPP	OIL SLUDGE	1	SN 13	3	-do-
21.	ORRP	OIL CONTAMINATED CLAY	1	SN 13	40	-do-
22.	TOP-I & TOP-II	USED OIL & SLUDGE	1	SN 5	8	• Used oil sold to parties who are having authorization with SPCB/MoEF/CPCB • Oil sludge disposed in hazardous waste pit.

23	LOCO SHED	USED OIL	1	SN 5	20	Presently the waste oil is stored in drums. The parties with valid authorization are being explored by RSP for selling.
24.		BATTERIES	A	1170	604	Sold to parties who are having authorization from SPCB/CPCB/MoEF
25.		ASBESTOS	2	B-21	0.1	Disposed in hazardous waste pit in CCD

Water analysis of RSP

The water sample was collected from the Rourkela steel plant clarifier and it was tested

Water sampling: Water was collected from the SSM clarifier.

Analysis of water: Water sample taken from the R.S.P. was tested with Water Testing Kit

Model: Orlab Water testing kit.

Table 3.4.24 Water Analysis of RSP

Sl. No	Parameter	R.S.P. Water value	Permissible limit Standard (IS: 10500-1991)
1	pH Value	7.1	5.50-9.00
2	Odour	Unobjectionable	-
3	Total hardness (as $CaCO_3$), mg/l	1256.1	600
4	Iron (as Fe), mg/l	0.8	1.0
5	Chloride (as Cl), mg/l	101.2	1000.00
7	Total alkalinity, mg/l	153	200
8	Calcium (as Ca), mg/l	47.4	200
9	Calcium (as $CaCO_3$), mg/l	118.5	600
10	Magnesium (as Mg), mg/l	276.43	100

11	Ammonia, mg/l	4.8	1.2
12	Phosphate, mg/l	0.459	5
13	Sulphate, mg/l	Below 40	400
14	Chloride dioxide	Nil	1

Result

The result obtained from the analysis of the water was that the pH level of the water was appropriate as per norms. Similarly Iron (as Fe), Chloride (as Cl), total alkalinity, Calcium, Phosphate, Sulphate was found to be below tolerance limit. Magnesium, Ammonia and total hardness of the water was found to be excess and values of both the parameters are all above the norm.

Discussion

The above report of water analysis indicates that the water quality is not totally safe as some of the parameters like magnesium and total hardness is approximately thrice and twice than the normal permissible limit respectively. Other parameters found in the water were found below the permissible limit. Some of the parameter like the concentration of magnesium as well as the total hardness of the water is exceeding the norm. Presence of ammonia found to be above the limit, this makes the water little toxic. Overall the water tested was found to be hard and little bit toxic.

3.4.5 WASTE MANAGEMENT IN R.S.P.

One of the major concerns of world steel industry is the disposal of wastes generated at various stages of processing. The global emphasis on stringent legislation for environmental protection has changed the scenario of waste dumping into waste management. Because of natural drive to be cost-effective, there is a growing trend of adopting such waste management measures as would convert wastes into wealth, thereby treating wastes as by-products. This has led to aiming at development of zero-waste technologies. The technologies developed to economically convert wastes of steel plants into wealth provide new business opportunities for prospective entrepreneurs. Such technologies which have been identified in the report through adequate deliberations are indicated below in two categories, namely technologies for gainful utilization of wastes in manufacture of conventional products and those for gainful conversion of wastes into altogether new products. Besides reutilization they are also reduced by taking mitigation measures and new technologies, for different waste or pollutants they are as follows: -

Gaseous waste management

A. **Sinter production**: - Pollution prevention opportunities for sinter manufacturing may include selecting feed materials to reduce the amount of organics introduced to the sinter process. However, these practices may not be a cost-feasible option, due to the large effort required to identify and segregate oily materials from less-oily materials. Wiling of mill scale using caustic solutions may be a better P2 option for reducing the oil content in the feed stream before its addition to the sinter grate. De-oiling and dewatering of sludges delivered to the sinter process also reduce the amount of organics released to the atmosphere and reduce the total energy required to produce the sinter from recovered materials.' Waste materials generated at iron and steel mills without sinter lines are either sent off-site for processing. Off-site processors may take the waste byproducts and separate zinc for reuse elsewhere and iron-rich materials for reuse at the iron and steel mill.

B. **Iron making**: - However, two changes in ironmaking technology, direct reduction ironmaking (DRI) and pulverized coal injection (PCI) can indirectly reduce HAPs emissions from the industry by reducing or eliminating the need for coke in the ironmaking process. Reducing the need for coke reduces the emission of HAPs from coke manufacturing, since many of the HAPs that could be released (and not recovered) from coal in the coke oven process are instead combusted in the blast furnace. Both of these ironmaking technologies are being incorporated into the industry for their contributions to reducing product cost and air pollution. An additional P2 benefit is that these techniques reduce the energy required to produce iron, thereby reducing air pollutant emissions from energy production. Direct Reduction Ironmaking (still under development in many countries and in early use elsewhere) represents a radical change in ironmaking practice. DIU creates iron from coal or gas, iron ore, and other materials, eliminating the need for coke in iron manufacture and thereby eliminating virtually all of the HAPs emissions associated with the production of coke that would have been required for ironmaking. However, DRI does not necessarily reduce the amount of metallic HAPs emissions associated with making iron, since the iron ore consumption (from which metallic HAPs are generated) is not changed. In the DRI process, coal, iron ore and limestone are charged into a liquid bath. Carbon and heat reduce the iron ore, generating CO and molten iron. HAPs volatilized from coal during the direct reduction process are presumably destroyed within the iron-making vessel

C. **Steel making management**: - One suppression method in current practice is to use natural gas to suppress oxidation of the steel in the tapping area while the steel is being transferred from the BOF to the transfer ladle. Some early advances are being made in direct steelmaking, which extends the DRI process from the manufacture of iron to the manufacture of steel. As currently conducted, the final output of the DIU process is iron that must still be converted to steel in a BOF. Direct steelmaking, like DRI, would greatly reduce the need for coke in the manufacture of steel, thereby reducing emissions from coke manufacture. Direct steelmaking also promises to reduce the total energy requirement for steel production.

D. **Finishing** :- Some suppression opportunities for the HAP generating from the finishing of the steel have been identified for this process area; most have to do with minimizing the use of acid or the prevention of excess HC1 or HF losses to the atmosphere.

Liquid waste management

The waste water which has been generated is first of used to extract some of the useful product from themselves and are further treated and disposed in the environment or in the river nearby or to any water source. Natures of products extracted during treatment of water are:-

A. First, the suspended matter: sinter plant dust, flue dust, steel plant dust and mill scale. This is of variable grain size, but generally small— from 0 to 100 Jim—settling well down to 10 Jim and containing much iron (30 to 60 per cent). This dust is collected, treated and returned to the fabrication line, except that from blast furnace gas when it contains elements which are harmful to the blast furnace, particularly zinc. Granulated slag. Soaked silicate, occurs in the form of grains a few millimeters in size, the bulk density of which may be less than one.

B. Clarifier separation, a conventional settling process in rectangular or circular tanks is used. Considering the outputs, flocculation is only seldom used: withdrawal of sludge is performed by means of pumps or, in the case of mill scale, by clamshells. The settled sludge is either thickened or dried in vacuum filters, according to its final use. Effluent containing oils to collect current oils, the conventional processes of natural filtration and collection by mobile troughs are implemented. The reclaimed oils are generally incinerated.

C. Cold rolling mill, In the case of cold rolling mill oils, there is not yet any satisfactory process. A flotation technique by hydrogen micro-bubbles originating from electrolysis is being developed, and a plant is in operation on an industrial scale.

D. Slag granulation effluent an efficient and commonly used means consists in directing the granulation waste waters into a filtering-bottom tank which removes the granulated slag grains whose bulk density is lower or higher than that of water. Blast furnace flue dust effluent containing cyanides it is difficult to apply the conventional cyanide treatments as the outflows are large (400 to 1300 m3/h per blast furnace, depending on its size) and the water contains much carbonate. If recycling is important with a passage across an atmospheric cooling agent, one benefits by a natural elimination which is accelerated by the polyphosphates, according to a process as yet unknown.

E. Coke plant effluent Biological treatment coupled with the conventional settling tank seems to be the only efficient process for coke plant wastes, but the investment and operating costs make even those with the best intentions shrink from it. In several coke plants, these waters were used for coke quenching by the wet method. Many drawbacks have contributed to the abandonment of this way of operation. In conjunction with the Basin Agencies, the iron and steel industry has resumed the study of biological processes, trying to find an economically valid compromise.

Solid waste

Solid waste utilization: Various steel industries in the country in the area of waste utilization which includes production of cement from BF slag, use of LD slag as a soil conditioner, LD slag recycling through sinter routes, manufacture of fly ash bricks and light weight aggregates, agglomeration and recycle of lime fines, reuse of refractory wastes products and use of coke breeze in sinter making utilization of blast furnace slag.

A. The blast furnace slag can be used in the preparation of materials such as ceramic glass, silica gel, ceramic tiles, bricks, etc. The devitrification behavior of different sizes of slag-derived glass was investigated using differential analytical techniques to determine the possibility of preparing glass–ceramic materials. The crystalline phases of slag were identified as gehlenite, diopside pyroxene and barium aluminium silicate. The difference in the glass–ceramic texture was observed by treating the sample at different crystallization temperatures. Both acicular and dendritic morphology have been identified in the sample heat-treated at 1050 °C. A slight variation in peak crystallization temperature with particle size indicated a bulk crystallization mechanism (Francis, 2004). The recovery of silica gel from blast furnace slag has been attempted by leaching with H_2SO_4, separation of gypsum, precipitation of silica gel at pH 3.2, followed by the washing of the raw precipitate. The ceramic tile was prepared from granulated blast furnace slag and common clay by mixing calcia-silica ratio at different proportions. The optimum compositions were found to be where calcia–silica ratio was in the range of 0.1–0.3. The mechanical strength and water absorption of the fired specimen were in the range of 28–38 MPa and 2.5–0.1%, respectively. The physical properties of the sintered specimen are explained on the basis of XRD and SEM analysis. Formation of wollastonite in the sintered compacts with finer grain size was found to be an important parameter for increase in strength. Crystalline and amorphous blast furnace slag can be used as an adsorbent of phosphate from water solutions. The adsorption kinetics measurements confirmed that a model involving pseudo-second-order reactions could describe the sorption of phosphorus on crystalline as well as amorphous slag. The phosphorus sorption follows the Langmuir adsorption isotherm. The adsorption characteristics of blast furnace slag on the removal of lead have been investigated as a function of pH, the metal ion concentration, the particle size and the amount of sorbent. It has been established that the process occurs with increasing pH and the efficient lead removal by granulated slag occurs at pH values lower than precipitation pH values. The equilibrium in the slag lead solution system is described by the Freundlich adsorption isotherm. The percentage of lead removal at equilibrium increases with increasing slag amount but the sorption capacity decreases. Depending on the conditions, a percent lead removal of 97–98% can be achieved. The results obtained could be useful for the application of granulated slag for the Pb-ions removal from industrial waste .

C. Utilization of blast furnace flue dust and sludge

The reuse of blast furnace flue dust in sintering plant or blast furnace has been hampered due to the presence of Na, K, Zn, Pb, Cd, S, cyanides, oils, etc. In blast furnace Na, K, S can cause operational difficulties or unacceptable hot metal composition. The performance of blast furnace is strongly affected for presence of alkali due to lowering down the softening and melting temperature of iron ore and sinters. Alkaline elements accumulate in blast furnace due to cyclic reactions and hinder the normal operations, loss of permeability of the burden, cracking of refractory bricks, etc. In addition to this alkali cyanides is likely to be formed cause environmental problems. Zinc has been regarded as a problem because it forms a circuit in the furnace resulting in extra coke consumption. The volatility of zinc and its condensation in cooler region of blast furnace cause serious problems. For dealkalification of blast furnace dust, acid leaching has been suggested to promote increased recycling of iron making. Besides that scrubbing, washing, leaching with $CaCl_2$, NH_4Cl, etc. has been carried out. The study carried out at Regional Research Laboratory, Bhubaneswar, India reveals that it was possible to remove around 75% of Na values by reducing the particle size. However the removal of potassium was restricted to 22% only [11].

D. Utilization of Steel slag

In the basic oxygen process, hot liquid blast furnace metal, scrap, and fluxes, which consist of lime (CaO) and dolomite lime (CaO.MgO or “dolime”), are charged to a converter (furnace). A lance is lowered into the converter and high-pressure oxygen is injected. The oxygen combines with and removes the impurities in the charge. These impurities consist of carbon as gaseous carbon monoxide, and silicon, manganese, phosphorus and some iron as liquid oxides, which combine with lime and dolime to form the steel slag. At the end of the refining operation, the liquid steel is tapped (poured) into a ladle while the steel slag is retained in the vessel and subsequently tapped into a separate slag pot.

Because the ladle refining stage usually involves comparatively high flux additions, the properties of these synthetic slag's are quite different from those of the furnace slag and are generally unsuitable for processing as steel slag aggregates. These different slags must be segregated from furnace slag to avoid contamination of the slag aggregate produced.

In addition to slag recovery, the liquid furnace slag and ladle slag are generally processed to recover the ferrous metals. This metals recovery operation (using magnetic separator on conveyor and/or crane electromagnet) is important to the steelmaker as the metals can then be reused within the steel plant as blast furnace feed material for the production of iron.

The use of steel slag as an aggregate is considered a standard practice in many jurisdictions, with applications that include its use in granular base, embankments, engineered fill, highway shoulders, and hot mix asphalt pavement.

E. Utilization of LD slag

LD slag can be utilized in many areas such as soil conditioners, fertilizers, recovery of metal values, etc. Experiments were conducted using pulverized LD slag for growing vegetables like tomato, potato, onion, spinach, and crops like wheat, in the acidic soil .The results show that by adding a concentration of slag of between 1.5 and 5.0 t/ha, according to soil type and its agricultural use, it is possible to achieve a proportional increase in the soil's pH as well as changes to the exchange complex. The result is improved quality and soil productivity. Production of fertilizers from steel manufacturing byproducts such as LD slag, semi-calcined dolomite and ammonium sulfate and their application in agricultural systems, viz. pasture farming, agro-forestry and forestry have been studied. Influence of these materials on the chemical composition of soil, grass and to the potential economic benefits of applying these new fertilizers to the soil were also evaluated.

Recycling of metal values

In addition to the fluxing characteristics of LD slag, the recovery of metal values from slag was carried out by different techniques. Smelting reduction technique was applied for the recovery of valuable metals such as vanadium and chromium from LD slag using a Tamman furnace. The degree of metallization of slag was 98% at 1600 °C at 30 min of time. The slag is also reduced in an electric furnace to separate the slag and metal. The recovery of metal values from steel slag was carried out by addition of small quantity of mineral additive into the molten slag followed by crystallization of the slag. The additive acts as nuclei for the crystallization of dicalcium silicate in the slag. The breaking of slag produces 65–80% slag and 10–15% chips.

Other applications

The LD slags are suitable materials for the base and sub-base layer of road because of the hard characteristics. Investigations on the mineralogy and physical properties of LD slag have shown that it would make an excellent road stone. Experiments on the weathering of slag, both on the laboratory scale and in stockpiles, have shown that the free lime levels will drop to a near-constant nonzero value after 9–12 months. The LD slag of various ages has been used in the construction of the wearing course of several works and public roads. Nippon Slag Association in Japan is researching converter slag utilization in port and harbor construction and the use of EAF oxidizing slag as concrete aggregate. A major area for utilization of LD slag is in ballast for railway tracks. The slag sample from Indian steel plants have been tested and found to satisfy the railway satisfaction for ballasts

F. Utilization of LD sludge

In order to maximize the use of LD sludge in sinter making, pre pelletisation of LD sludge is highly essential. Pilot plant trials successfully demonstrated the viability of recycling million of tons of steel plant dusts and sludge that are now typically land filled, and typically converting them into useful products, i.e., hot metal for steel production, zinc-rich raw material for the nonferrous metal industry, and slag for road bed and cement production. The pilot plant trials and subsequent feasibility study showed that steel plant waste oxides could be smelted in an environmentally sound manner for an attractive return on investment.

The carbothermic reduction of sludges without addition of coal under nitrogen atmosphere for conversion to metallic iron has been reported. The results indicated that increasing the weight ratio of sludge, size of solid sample, carbon content, and density of solid sample or reaction temperature could increase the reduction rate However for direct use of this type of sludge briquetting or pelletisation is important to agglomerate the fines.

The agglomeration studies carried out at Regional Research Laboratory indicated that, LD sludge as such do not give enough strength of the briquettes. However it was possible to get adequate green strength as well as the crushing strength so as to recycle in the plant by using LD sludge in combination with mill scale. The combination of binders plays a vital role in the formation of the agglomerates. In order to have sufficient green strength for pellet making, a minimum of 2% lime and 6% of organic binder is required. Drying of pellets at 110 °C for 1 h, the crushing strength of the pellets increased considerably. It was also observed that around 8–9% of inorganic binder is required for making pellets.

CHAPTER 4

CONCLUSION

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Waste management in mining and allied industries has presently assumed greater importance. It is a technique in managing wastes in such a way that it would be beneficial in any way. Waste management is the collection, transport, processing, recycling or disposal of waste material, usually one produced by human activities with an effort to reduce their effect on human health or local aesthetics or amenity. Waste management involves solid, liquid and gaseous waste management.

The types of waste generated by mining and allied industries can pollute the environment because of to its chemical (or physical) nature in particular media as water, soil, vegetation, and targets like the fauna and human. Waste management helps in reducing pollution by environmental friendly waste disposal system is possible due to the implementation of these processes. Disposal of mining and steel plant wastes demands due attention in planning and execution in order to achieve environmentally acceptable disposal practice so that environmental problems can be eliminated. Waste management helps in effective managing the waste generated and helps in better utilization of raw materials.

Field study was carried on waste management in the different mines and in Rourkela steel plant. The objective of the study was to know the status of waste management practices in the mining and steel industries, to know the sources of waste generation and whether the waste management practices followed was sound and benign.

From the field study of BSL mines it was concluded that major waste problem for the mine is the generation of the overburden and dust emission from mines and from the crusher area. These waste generated from the mines are not hazardous in nature. For the disposal of overburden they were using two waste dumps. The management of the solid waste generated i.e. overburden is disposed in the two dump of the mine, further this waste is used for paddy harvesting or in plantation. For the management of particulate matter water sprinklers were used in the mines for the dust suppression. Water sample of BSL mine was analyzed. In the result it was found that the concentration of magnesium and ammonia in the water sample was in excess. Soil sample of BSL mine was analyzed. BSL mines soil sample result shows that the soil lacks organic carbon and soil nitrogen.

Suggestions for improvement for waste management practices in the BSL mines are the overburden generated should be directly used for the landfilling or reclamation of the mines. More Number of water sprinklers should be used and there should be utilization of mine water.

In Basundhara open cast mines the main sources of waste or area for waste generations are mine quarry, excavation workshop, overburden dumps. The major problem of waste is from the effluent water and discard batteries of the HEMMs from the excavation workshop, these waste generated are hazardous and need proper treatment before disposal. Effluents containing hazardous substance are treated and disposed into impermeable pit and the discarded waste batteries of HEMMs are sold to the authorized persons.

Soil sample of Basundhara mines was analyzed. From the result of Basundhara mine soil sample analysis it was concluded that the soil sample lacked organic carbon and soil nitrate nitrogen. As in Basundhara open cast mine, dust control was ineffective in the mines, it can be improved by using special chemical sprinkling for the dust suppression that will arrest the dust to become air-borne and eliminated efficiently.

In Hirakhand Bundia underground coal mines the major waste problem is from waste water. The liquid waste generated from the mines is not properly handled. The surface oil and grease trap is not working properly in the mines as they are using settling tank for separation of grease and oil from the water. Mine should use oil and grease trap specifically to efficiently separate the water from the effluents that are mixed in the water. Some of the part in the mine is face dust problem. To control dust regular cleaning of travelling roadway floor should be done to avoid dust problem. The suggestion for improvement of waste management practices in the Hirakhand Bundia mine underground coal mine as coal dust and treatment of water were major problems. Regular cleaning of the mine and proper dust suppression measure should be taken at coal face, travelling and loading point. Oil and grease trap should be used for the treatment of mine water.

In Rourkela Steel industry there are significant quantities of solid, liquid and gaseous wastes are generated as a waste material or byproduct every day from steel industries. These wastes can be hazardous or non-hazardous depending on their characteristics. Disposal of these wastes into the environment can pose serious threat. So, proper management of waste is required in the steel industry. Different techniques are used for the disposal of hazardous and non-hazardous waste in RSP. Solid waste usually contains considerable quantities of valuable metals and materials. This solid waste from one form to another to be reused either by the same production unit or by different industrial installation is very much essential not only for conserving metals and mineral resources and also for protecting the environment.

The main sources of hazardous waste generation in RSP are from coal chemical department, rolling mill, silicon steel mill and loco shed etc. Disposal of the hazardous waste generated from these departments are disposed in scientifically designed hazardous pits as per the guidelines of Central Pollution Control Board. Some of waste that are generated such as zinc dross, palm sludge, used oil and acids which are hazardous in nature but further can be utilized are sold to private parties who have authorization from SPCB/CPCB/MoEF.

In case of non-hazardous waste the major problem is by fly ash, SMS slag and sludge. These solid waste generated from the Steel Plant cannot be utilized due to various constraints and limitation. Due to their lack of utilization, their disposal is becoming a great concern. Among the three solid wastes fly ash disposal in RSP is a big problem. As fly ash rate of generation is very high as compared to the other two wastes and therefore the area required for the disposal of fly ash is very large. However the fly ash and SMS sludge generated are disposed in the fly ash pond and SMS sludge pond respectively. RSP presently, is unable to utilize 100% of SMS Slag and sludge. The percentage utilization of the SMS Slag and Sludge is below 50%. So various research works are going in the R&D unit of RSP to utilize these two wastes. Water sample of RSP was analyzed. For RSP water sample magnesium, ammonia and total hardness was found to be in excess.

The suggestions for improvement of waste management practices in RSP are that the fly ash can be utilized for brick manufacturing and can be supplied to the nearby mines and low-lying areas for backfilling. SMS slag can be used in rehabilitation of the land. So initiative should be taken to promote and utilize the SMS slag by supplying it to the areas that needs rehabilitation.

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